PAMPHLET COLL.
FILE UNDER:
ASSOCIATED FACTORY, etc.

# DRY ROT
# IN
# FACTORY TIMBERS

IMPERIAL BUREAU OF MYCO
28 JUN. 1921

1915

PRICE, 25 CENTS

INSPECTION DEPARTMENT
Associated Factory
Mutual Fire Insurance Companies
31 Milk Street, Boston, Mass.

# SPECIFICATIONS

## Suggested for a Special Grade of Longleaf Pine For Use in Mutual Factories

In making contracts for beams, columns and plank to be used in "Slow Burning Construction," the following specifications are recommended for reasons given in the following pages.

**Density.** No part of the material shall have a density of less than 30 pounds per cubic foot when tested by boring smooth holes one inch in diameter and two inches deep in the ends of the stick, drying to constant weight at 212° F. and weighing the borings and computing the density from the volume of the hole.

**Rosin.** None of the heartwood shall show less than four per cent of rosin by weight when borings are taken with a one inch bit with a hole two inches deep, dried to constant weight at 212° F. and extracted with benzole, the extracted rosin evaporated until it is not soft or sticky when touched with the finger at 70 ° F.

**Heartwood.** Heartwood shall show the entire length in all four faces of every stick, and sapwood shall not extend more than two inches from the corner at any place, measured perpendicularly to the corner across the face.

**Growth Rings.** For timbers 6″ x 8″, or larger, there must show on the cross section between the third and fourth inch, measured radially from the heart center or pith, not less than six annual rings of growth, a majority of which shall show at least one-third summerwood, which is the dark portion of the annual rings; but wide ringed material excluded by this rule will be acceptable, providing that in the majority of the annual rings the dark ring is hard and in width equal to or greater than the adjacent light colored ring.

For pieces in which the center is not included, there must show on the cross section, an average of not less than six annual rings of growth, with not less than one-third summerwood. Timbers will be rejected in which there is no sharp contrast in color between the springwood and summerwood.

**Defects.** No timber with knots greater than one inch in diameter, or rot, or injurious shakes will be accepted.

**Branding.** Longleaf pine sold under this specification shall be branded with the letters "F. M.," the name of the lumber manufacturer, the location of the saw-mill from which it comes, and the date of sawing, in letters at least one inch high.

**Note.** Further details are given on page 68. When resistance to decay is to be secured by chemical treatment, poorer timber can be used, specifications as to defects, densities, etc., being so written as to assure the required strength. See pages 76 to 82. Common timber with thorough chemical treatment can probably be bought at a lower price than the special grade described above and for most purposes will be equally serviceable.

INSPECTION DEPARTMENT
OF THE
Associated Factory
Mutual Fire Insurance Companies
31 Milk Street, Boston, Mass.

MARCH 15, 1915.

# DRY ROT
IN
# FACTORY TIMBERS.

---

**The interest of the Factory Mutual Insurance Companies in Dry Rot of Timbers is threefold.**

**FIRST: They have for fifty years been sponsors for so-called slow burning or mill construction. The economy and integrity of this excellent type of building is threatened by the remarkable increase in the prevalence of dry rot during the past few years.**

**SECOND: Wood infected by dry rot ignites more easily than sound wood and mill timbers with rotted ends fall more quickly under fire.**

**THIRD: The officers and engineers of these companies believe that the dangers of dry rot can be largely eliminated, with the consequent saving of many thousands of dollars to Mutual members.**

No. 32.
2d Edition.
5000-3-15.
1300 4-15.
2500-11-16

Copyright, 1915, by
C. H. PHINNEY, *Trustee.*

## BRIEF ABSTRACT OF FOLLOWING HUNDRED PAGES.

1. Thirty cases of dry rot, of greater or less magnitude, have been brought to the attention of the Mutual Companies within the past three years. Several million feet of lumber were involved, and, in some of the worst cases, the **safety of important structures was menaced.** There were undoubtedly many other cases which have not been reported. The direct money loss to Mutual members from this source is undoubtedly many thousand dollars each year in addition to the increased fire and life hazard from loss of strength and **greater combustibility** of rotting structural timbers.

2. The varieties of fungi causing this destruction of factories are apparently few, and, while their habits and requirements are not well known, it is evident that the **supply of moisture and the temperature are important controlling factors.**

3. Each variety of timber has its own peculiar fungus destroyers, and, as the number of varieties of timber practically available for mill construction is limited, the problem is somewhat further simplified and resolves itself into the **selection of timber** with the greatest natural resistance to fungi practically attainable, and seeing that this is dry and **free from dangerous living fungi** when placed in the structure.

4. In most cases, it is **well worth the cost to thoroughly heat the building** by use of its heating system as soon as possible after it is completed. This will hasten the drying and **kill surface growths of dangerous dry rot fungi.** This may fill all requirements in buildings of dry occupancy.

5. The moist atmosphere present in such processes of manufacture as paper making and cotton weaving, introduces conditions which probably no variety of wood now practically obtainable can withstand continuously without having its natural resistance to fungi **reinforced by artificial antiseptic treatment.**

6. Timber of uniformly high natural resistance to fungi is difficult, if not impossible, to obtain by grading methods now in general use. The dense resinous longleaf pine from the butts of trees, which has been used in the past, has proved satisfactory. The present supply of so-called "**Commercial longleaf pine,**" **comprising all varieties of Southern pine,** (North Carolina, shortleaf, loblolly, and Cuban, mixed indiscriminately with

true longleaf), **is proving far less reliable** than the supply of former years, and thus far **no standard specifications have been adopted by means of which the purchaser can assure himself of the reliability of the lumber delivered.**

7. The percentages of **rosin** and the **density** are undoubtedly valuable indices of durability and strength. The rosin test is somewhat cumbersome to apply and is not recognized by the lumber trade. The density is roughly covered in the "Growth ring" or "Grain band rule" recently adopted by several lumber associations.

8. It is probable that a close observer, who has had considerable experience with Southern pine, could select resinous dense wood with considerable certainty, and it would doubtless be worth while for a large user of Southern pine to employ such a man as buyer at the saw-mills. This is done by some of the German lumber importing companies. It is, of course, **necessary to pay a premium for such selected timber,** but it is well worth it, as an unreliable wood in an important structure would be expensive even as a gift. This plan is impracticable with the small or occasional purchaser, and to such the only course that can be at present recommended is to **buy heartwood timber, of which the density, as indicated by the grain bands, is sufficient to insure the required strength, and to give this a chemical treatment** of sufficient antiseptic power to kill any latent fungi that it may contain and to protect the surface from later attack.

9. The process of antiseptic treatment, which, from the small amount of experience thus far available, appears to be best adapted to use on mill timber, is to **soak it for a week in a one per cent solution of corrosive sublimate** dissolved in water. This has been done at the mills in several cases recently, the treatment, with good heartwood, costing about three dollars a thousand. **Lumber already treated with corrosive sublimate can be obtained commercially, at a reasonable price,** where it is desired to avoid the inconvenience and delay necessary for treatment on the job. When such treated timber is used, care should be taken to thoroughly swab with corrosive sublimate solution all parts of the interior of the stick that are exposed by cutting after the treatment is applied.

## RECENT PROGRESS.

Since the publication of the first edition of this pamphlet in December, 1913, considerable progress has been made towards assuring more reliable timber for mill construction.

The problem divides itself into two parts:

First, that of untreated timber, or the possibility of securing uniformly reliable timber at a permissible price, which possesses sufficient natural resistance so that unaided it can withstand fungus in the moist atmosphere found in many rooms in textile mills, or in paper mills.

Second, that of timber treated antiseptically, or timber which can be had in suitable lengths and sizes, with sufficient strength for the required load, and which can be given the necessary resistance to fungus by chemical treatment.

In the past, good quality longleaf pine has given satisfactory service without antiseptic treatment; but the present supply, which comprises much loblolly, shortleaf and poorer longleaf, is lacking in natural resistance. Therefore, in order to make sure of obtaining a grade of Southern pine which can be used safely without antiseptic treatment, **the present system of grading must be revolutionized,** and based upon those physical and chemical properties which underlie strength and resistance to fungus rather than upon the vague botanical distinctions now in use.

During the past year, on behalf of the Factory Mutuals, I have visited longleaf pine forests and saw-mills in Louisiana, Alabama and Mississippi. By request, I attended the annual meeting of the Yellow Pine Manufacturers Association in New Orleans in order to explain the requirements of so-called "mill construction." The statement of our case was received with great courtesy, and this organization showed its interest in the subject by voting to have research work, tending to conserve the good qualities of their lumber, carried on at the Missouri Botanical Gardens in St. Louis. The Association also has under consideration new grading rules for structural timber.

The Forest Products Laboratory of the United States Department of Agriculture has become much interested. I accepted an invitation to visit the Laboratory at Madison, Wisconsin, and discussed the problem, and two representatives of this

Laboratory have recently visited some of our textile mills, to study the conditions under which dry rot occurs. It is understood that they have laid out a large amount of additional research work for the coming year. This is probably the only institution in the country which has suitable facilities for carrying out this work in the comprehensive manner that is required, and, finally, it probably will be upon the results of work to be done by their experts, on the causes of resistance to fungi, the habits of important wood destroying fungi, and preservative processes, that permanently useful specifications for structural timbers can best be based.

The Committee on Grading Rules for Structural Timber, of the American Society for Testing Materials, has been enlarged and several subcommittees formed for the purpose of reconsidering timber specifications.

Several factories insured in the Mutuals have, at our suggestion, during the past season, soaked pine and spruce planks for roofs in a weak solution of corrosive sublimate, in tanks located in their own yards, **and have found that this process of wood preserving is easily carried out and the cost small.** Photographs are shown in Figures 67, 68 and 69 of some of this work in progress. Other mills, seeking immunity from quick decay of timbers, have used coal tar compounds, and in two or three cases corrosive sublimate dissolved in wood alcohol has been used when the time for treatment was limited, or the timber was already in place and therefore could not be soaked in a tank. In a few cases, as suggested in our pamphlet of December, 1913, to arrest decay already begun, the **timbers have been more or less sterilized by temporarily raising the interior temperature of the factory** by means of its own heating system.

## EXTENT OF THE DESTRUCTION.

**The loss to Mutual mills from rotting timber is many thousands of dollars a year.** It is not possible to state the amount with even approximate accuracy. The following photographs will convey come idea of the character and extent of the destruction in a few cases.

FIGURE 1. PART OF 239,000 FEET OF SPRUCE ROOF PLANK AND HEMLOCK FLOOR BEAMS REMOVED FROM A MASSACHUSETTS COTTON FACTORY DUE TO ROTTING IN FROM TWO TO FOURTEEN YEARS.

FIGURE 2. OAK COLUMNS AND WHITE PINE FLOOR BEAMS REMOVED FROM AN ENTIRE FLOOR OF A FACTORY IN ONTARIO, CANADA, AND REPLACED BY STEEL AFTER TWENTY-FIVE YEARS OF SERVICE. INFECTION WAS APPARENTLY RECENTLY INTRODUCED IN NEW LUMBER USED FOR A BASEMENT FLOOR.

FIGURE 3. SEVENTEEN 12″ x 16″ SOUTHERN PINE BEAMS ROTTED AND REMOVED AFTER TWO YEARS' SERVICE IN A COTTON FACTORY IN CONNECTICUT.

FIGURE 4. PART OF 750 8″ x 18″ BEAMS REMOVED FROM A NEW FACTORY IN MONTREAL, AFTER ONLY THREE YEARS' SERVICE, BECAUSE RENDERED UNSAFE BY DECAY.

FIGURE 5. AN OLD PAPER MILL WITH HEMLOCK FRAME ROTTED SO BADLY THAT IT WAS ABANDONED, SHOWING OPENING WHERE FLOOR HAS FALLEN.

FIGURE 6. FUNGUS FOUND GROWING ON UNDERSIDE OF ROOF PLANK IN A NEW YORK CANNING FACTORY. (Camera pointed vertically upward.)

FIGURE 7. TIN CLAD FIRE DOOR OF WHITE PINE, BADLY ROTTED ONLY THREE YEARS AFTER IT WAS INSTALLED IN A MASSACHUSETTS COTTON FACTORY.

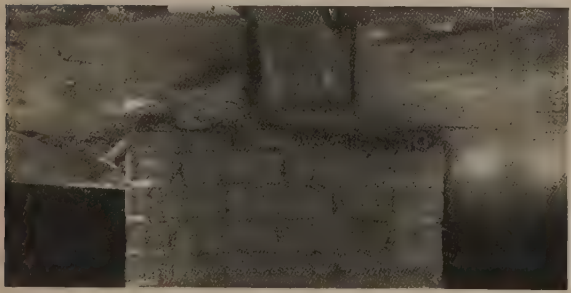

FIGURE 8. HEMLOCK BEAM, ROTTED AND CRUSHED UNDER A LIGHT LOAD, AFTER TWO YEARS' SERVICE IN A MOIST BASEMENT. THE ADJACENT LONGLEAF PINE COLUMN IS STILL SERVICEABLE AFTER FOURTEEN YEARS.

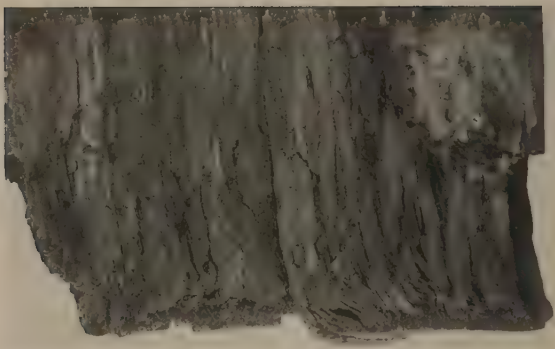

FIGURE 9. ROTTED COLUMN CRUSHED IN AN OHIO PAPER MILL. THE TIMBER IS LOBLOLLY PINE. THE ROTTING WAS APPARENTLY STARTED BY THE TIMBER BEING SOAKED BY A FLOOD

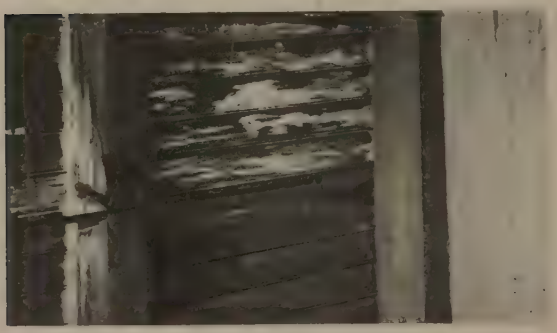

FIGURE 10. FUNGUS GROWING ON SOUTHERN PINE ROOF PLANKS AND BEAMS OF A CHICAGO STOREHOUSE. THE BUILDING IS INFECTED THROUGHOUT. THE FRAME IS BEING REINFORCED AND PART OF ONE FLOOR HAS BEEN REPLACED WITH CONCRETE. (Camera pointed vertically upward.)

## DRY ROT AND FIRE HAZARD.

**Partly rotten wood ignites much more easily than sound wood.**

Dry rot in factory timbers is of importance not only from the cost of replacement and the danger of collapse, but because it increases the fire hazard. The increased combustibility of rotted fence posts and stumps is familiar to many casual observers. The collapse of the Gledhill Wall Paper Factory of New York, after a small fire,[1] presented an illustration of this hazard.

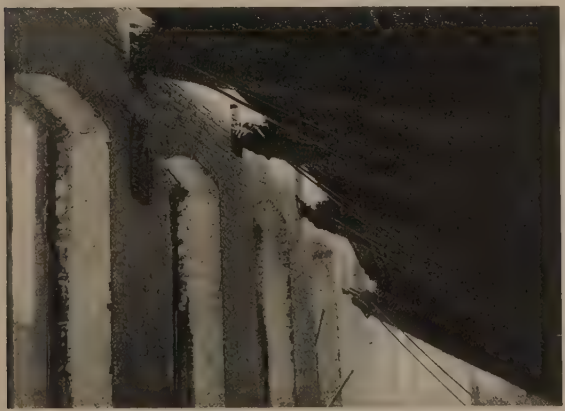

FIGURE 11. SHOWS ENDS OF MILL BEAMS COMPLETELY DESTROYED ALTHOUGH THE BEAMS THEMSELVES ARE NOT DEEPLY BURNED.

1. Engineering News, Vol. 62, 1909, page 620.

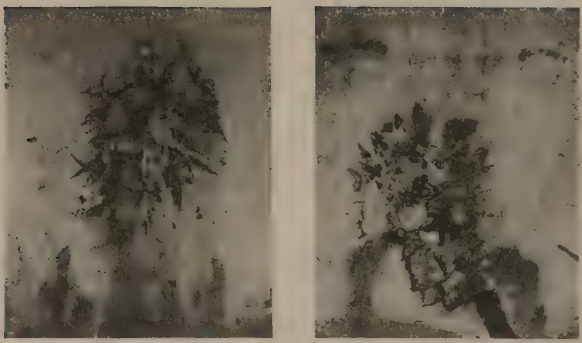

FIGURE 12. SHOWS TWO SECTIONS OF 14″ x 16″ WHITE PINE BEAMS, WITH ROTTED CENTERS, WHICH WERE RECENTLY REMOVED FROM ONE OF THE OLDER COTTON MILLS. WHEN LIGHTED WITH A MATCH, THEY CONTINUED TO BURN UNTIL ALL OF THE ROTTED WOOD WAS CONSUMED.

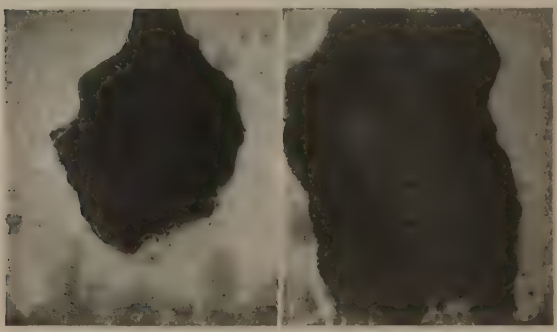

FIGURE 13. FLOOR BEAMS DESCRIBED ABOVE AFTER THE IGNITED ROT HAD BURNED AWAY, THE FIRE GOING OUT OF ITSELF WHEN IT REACHED THE SOUND WOOD.

## THE INCREASED COMBUSTIBILITY OF WOOD AFFECTED BY DRY ROT.

The ignition point of rotted wood has been shown to be **lower than that of sound wood.**[1]

Under favorable conditions, large pieces will ignite at a temperature of 290° F., or even lower.

The Mutual Companies have no definite records of increased losses from this source, owing, doubtless, to the efficiency of the complete automatic fire protection in Mutual risks, by means of which the fire is ordinarily extinguished before the fire resistant qualities of the construction are severely tried.

1. Henry B. Hill, Proceedings of the American Academy of Arts & Sciences, Vol. 22, 1886, page 482.

## SUGGESTIONS FOR EXAMINING AN INFECTED MILL.

In examining a mill affected with dry rot, it is especially desirable to determine how far the rot has extended, whether it is still alive and whether it is of a variety which goes into a resting state and may, therefore, be revived at any time when the conditions of moisture become favorable; also, whether it is a variety which may be destroyed by moderate heating or drying.

The extent of the rotting can generally be estimated approximately **by boring test holes** into the beams and columns at frequent intervals. If the material is badly rotted, the chips brought out will be in the form of a brown powder or mud, according as the wood is dry or wet. Sometimes, where the rot has not progressed so far as to entirely destroy the structure of the wood, the chips are browner than the sound wood and more brittle.

**Hammering on the timber with the round end of a machinist's hammer** is also sometimes useful where the wood is in an advanced state of decay. In some cases, where this test has been applied, the outer shell of apparently sound beams has been broken through, showing the entire destruction of the interior. The rotting in roof planks is generally much worse above the beams than in the middle of the bay, and, in some cases, planks which appear sound on the exposed surface will be found rotted above the beams so that a knife blade can be pushed entirely through them.

**To determine whether the rot is still alive** is frequently a more complicated matter. If it is growing vigorously on the surface of the wood, the fresh growth of lace-like plants is significant, but **the more frequent condition is where the dry rot fungus is growing inside the wood with no outward manifestation.** In this case, a strong indication of living fungus is the moist appearance of a freshly cut section. In some cases, moist spots will remain for several days on such a section when left in a comparatively dry room. The only positive test, however, is to cut a large number of blocks about $2\frac{1}{2}''$ cube from the wood at the point where the rot just ceases to be apparent by the brown color, so that a part of each block is brown and a part of it has the appearance of sound wood. These should be placed in fruit jars and soaked in water containing $2\%$ of citric or tartaric acid for about six

hours, then the water should be poured off and the jars covered and left at a temperature of about 75° F. for two or three weeks. If long threadlike growths, such as those shown in Figure 14, appear on any specimens, the fungus is doubtless alive and of a suspicious variety. Microscopic molds of various colors not infrequently appear on such cultures, but they do not indicate a wood destroying fungus.

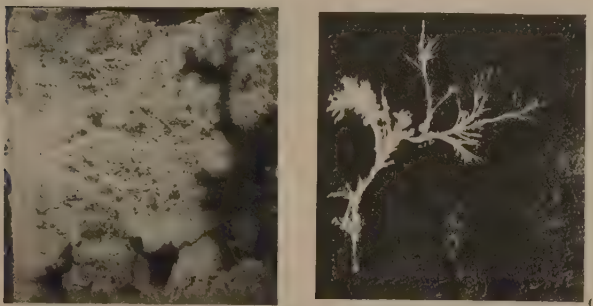

FIGURE 14. STERILE ROT PLANTS AS COMMONLY SEEN. THESE PLANTS WERE CULTIVATED ON SMALL BLOCKS IN FRUIT JARS. SCALE ONE-HALF NATURAL SIZE.

**The culture blocks will not only show fungus in active growth, but also living fungus in a resting state.** This is the only sure way in which fungus in this treacherous state can be discovered. Microscopic examination of sections would show whether they contained the bulb-like formations indicating the resting state, but would not show whether, or not, they were alive. It is very rare indeed that fruiting plants, whether of the dry rot or other varieties, are found on structural timbers above the basement. Therefore, spores, the normal reproductive body, are probably not common causes of perpetuating the disease in factories. Such fruiting plants are moreover very easily seen and identified unless they are growing inside of hollow partitions or in concealed basements, as sometimes occurs.

**Some kinds of dry rot fungi can sometimes be arrested by heating,** while, with some other varieties, this is not effective. Where there are no fruiting plants, the only practicable course is to judge, from the location of the rotted lumber, the probable

sensitiveness to heat, of the fungus causing the destruction. For example, a rotted roof plank in a paper mill or weaving mill, with the normal temperature from 80° F. to 100° F. at the roof, and frequently in summer higher than this, would not be expected to contain a variety of fungus which could be killed by heating to 115° F., while with rot discovered in the beams or columns of a moderately dry mill, with an average temperature of 70° to 80°, heating would be worth a trial without further evidence as to the exact variety of fungus present. If fruiting plants are found, the plan of procedure may be somewhat simplified.

## HOW WOOD ROTS.

Rot in wood was originally supposed to be a chemical action similar to rusting of iron, and the delicate lace-like plants, tough brackets, or brown leathery growths, were supposed to be attracted by the decayed wood rather than being the cause of the rotting. About 1870, it was shown by Hartig and others in Europe that fungi were the cause of rot instead of a result of it. The chemistry of the rotting process is not well known at the present time. It is probable that there is some chemical action in addition to the life progress of the fungus through the wood cells. It is noted in blocks of sound wood, in which fungus has been cultivated, that **when the fungus is freshly removed from the moist wood, it has the appearance of being bright and sound as ever;** but, after being left in a dry atmosphere for a time, the wood shrinks and forms the characteristic brown, cracked, and powdery material which is familiar as rotted wood.

Without doubt, the fungus ceases to make any vital progress very soon after the drying commences, and the final browning and powdering is brought about by oxidation by the air, assisted by certain organic enzymes, either already present in the wood cells or formed by the activity of the fungus. A phenomenon which supports this theory is that the plants of certain wood destroying fungi when folded in a piece of white paper discolor it, changing it to a brown substance, probably an oxy-cellulose, leaving a fairly well defined impression of themselves upon the paper. They will also form a developable image on a photographic plate in the dark.

It is customary in many lumber yards, particularly where Southern pine lumber is sold, to pass the planks and timber through a planer immediately before delivery. This not only smooths the material, but removes all fungus plants and **leaves a bright surface which can be easily mistaken for sound wood,** if it is used before drying has brought out the brown spots which are recognized as rotten wood.

## NAMES OF THE COMMON TIMBER-DESTROYING FUNGI.

**There are but few common or popular names for fungi,** and the few there are, such as dry rot, punk, toadstools, etc., are exceedingly vague and indefinite. The Latin names are commonly used in scientific literature. Their use implies an exact identification.

In this pamphlet, the words **"dry rot"** are used to signify broadly the following fungi:

*Merulius lachrymans*. Figs. 15 and 16, and other members of the *Merulius* genus.

*Coniophora cerebella* (or *Coniophora puteana*). Figs. 17 and 18.

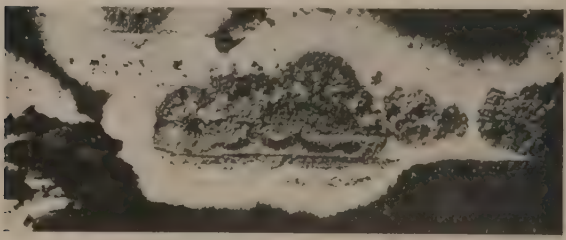

FIGURE 15. MERULIUS LACHRYMANS, OR DRY ROT, WITH FRUIT, ON BEAM REMOVED FROM COTTON FACTORY IN CANADA. SCALE ONE-THIRD NATURAL SIZE.

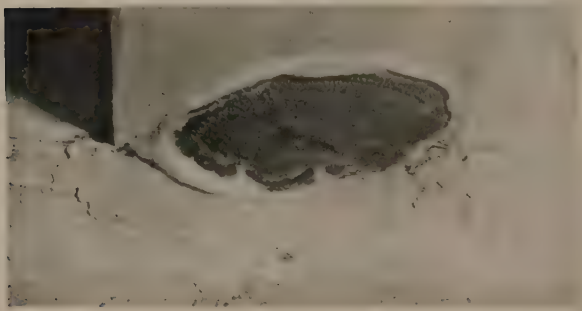

FIGURE 16. MERULIUS LACHRYMANS GROWING ON A SOUTHERN PINE BEAM IN THE BASEMENT OF A COTTON STOREHOUSE IN RHODE ISLAND. SCALE ONE-THIRD NATURAL SIZE.

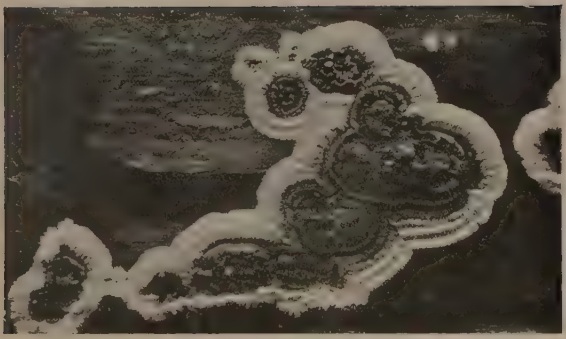

FIGURE 17. CONIOPHORA, WITH FRUIT, ON A BEAM REMOVED FROM A COTTON FACTORY IN CANADA. SCALE ONE-THIRD NATURAL SIZE.

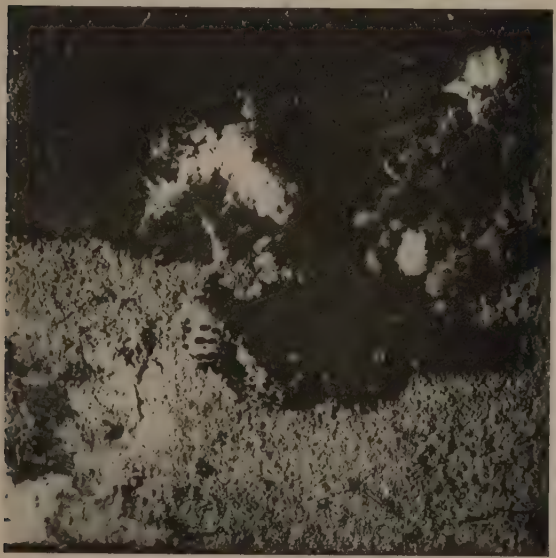

FIGURE 18. CONIOPHORA ON A HEMLOCK BEAM IN A BASEMENT OF A MASSACHUSETTS COTTON FACTORY. SCALE ONE-QUARTER NATURAL SIZE.

**The dry rot disease is widely distributed in this country,** but it has been more carefully investigated in Europe, especially in Germany. Forty dry rot cases have been brought before the German courts within the last ten years.[1]

In past years, little careful study has been given to the disease in this country, but the occasional cases recorded[2] indicate that it was more a question of the general use of material of high natural resistance than the absence of the disease. The fact that the disease recently has shown itself on susceptible material in widely separated parts of the country, at about the same time, adds weight to this theory. Within the past three years, I have found well defined fruiting plants of the *Merulius lachrymans* in Quebec, Ontario, Massachusetts, Rhode Island, Louisiana and Mississippi. *Coniophora* has been found in Quebec and Massachusetts.

**Fruiting fungi can be easily identified,** but it is difficult or impossible to positively identify the young sterile growth.

**The chief use in identification is to help in determining the best curative measures to apply.** For example, the *Lenzites* can stand high temperatures, nearly up to the boiling point of water,[3] while the dry rot family are killed at a comparatively low temperature, which peculiarity suggests a curative process to be explained later on.

1. Hausschwammforschungen, Vol. 2, 1908, and Vol. 5, 1911.
2. Charles T. Main, Notes on Mill Construction, page 31.
3. Hausschwammforschungen, Vol. 3.

The name **Polyporus family** (fungi having many pores) has been used to include broadly any of the pore fungi having pores or holes of various sizes and shapes in the fruiting surface. Members of this family, which are conspicuous for the destruction which they have caused, are *Fomes roseus* (or *Fomes carneus*), Figures 21 and 22, *Trametes serialis*, Figure 20, and *Lenzites sepiaria*. The last has pores shaped more like gills, see Figure 19, and is very active in destroying storehouse platforms. A few plants of this variety have been found on weave shed roof planks. It may be important as a destroyer of weave shed and paper mill roofs, but more investigation is needed to establish that fact.

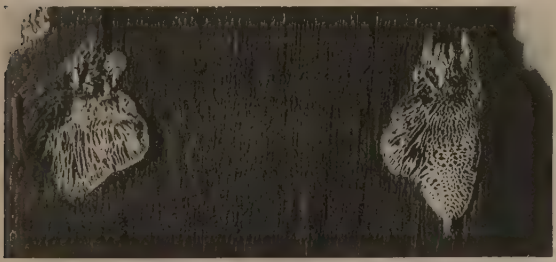

FIGURE 19. LENZITES SEPIARIA ON SPRUCE ROOF PLANK REMOVED FROM A MASSACHUSETTS COTTON FACTORY, SCALE FULL SIZE.

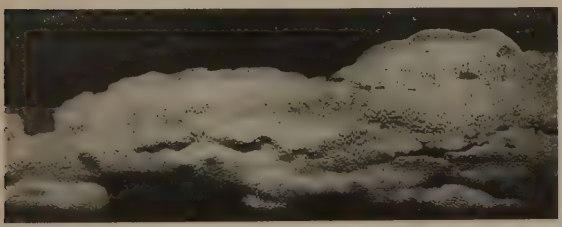

FIGURE 20. TRAMETES SERIALIS FROM BASEMENT OF A MASSACHUSETTS COTTON FACTORY. SCALE FULL SIZE.

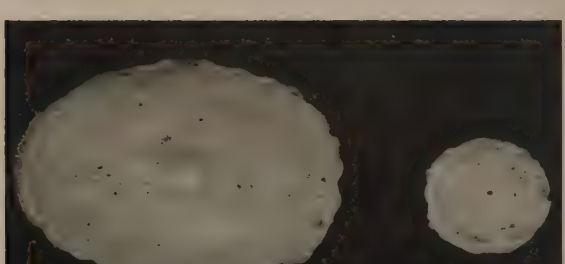

FIGURE 21. *Fomes roseus* (a hard rose tinted fungus) ON BEAM FROM A PAPER MILL IN NORTHERN NEW YORK. SCALE ONE-HALF NATURAL SIZE.

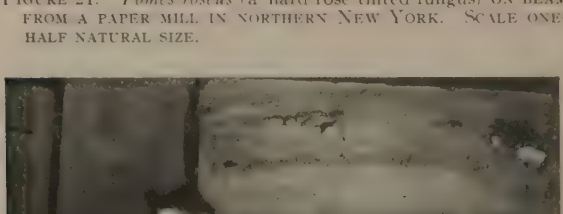

FIGURE 22. *Fomes roseus* ON A HEMLOCK BEAM IN A MOIST BASEMENT OF A MASSACHUSETTS COTTON FACTORY. SCALE ONE-TENTH NATURAL SIZE.

**In many cases, owing to the absence of fruiting plants, the particular kind of fungus causing the destruction cannot be determined.** It is generally impossible to tell with any degree of certainty, from the appearance of the rotted wood what fungus is responsible for the destruction.

There is undoubtedly difference in the microscopic appearance of the fungus plants in the wood cells, as can be seen from some of my photo-micrographs, reproduced in Figures 23, 24 and 25, but their peculiarities have not been much studied or described in the treatises available.[1]

1. Zersetzungserscheinungen des Holzes, Robert Hartig, 1878.

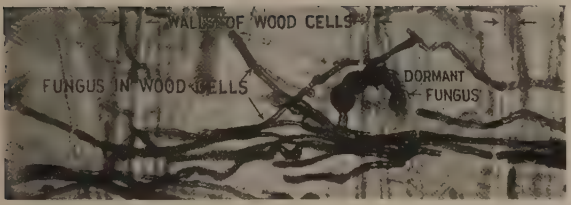


FIGURE 23. CONIOPHORA IN LOBLOLLY PINE WOOD CELLS, MAGNIFIED ABOUT 400 DIAMETERS. SECTION TANGENT TO THE TREE.

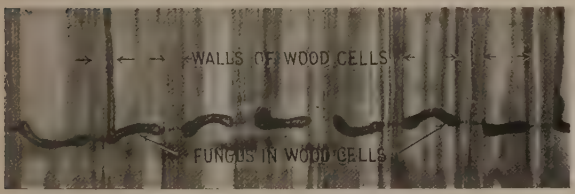


FIGURE 24. FUNGUS PASSING THROUGH LOBLOLLY PINE WOOD CELLS, PROBABLY TRAMETES SERIALIS. MAGNIFIED ABOUT 400 DIAMETERS. SECTION TANGENT TO THE TREE.

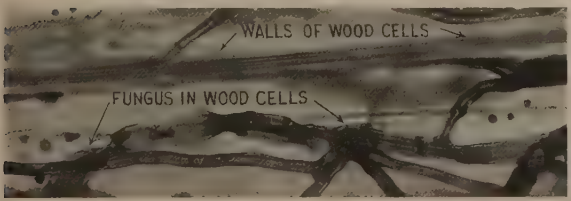


FIGURE 25. CERATOSTOMELLA PILIFERA, OR BLUE SAP PINE FUNGUS, IN WOOD CELLS. MAGNIFIED ABOUT 400 DIAMETERS. SECTION TANGENT TO THE TREE.

## THE RAPID PROGRESS OF DRY ROT.

**In most cases, the rotting found has taken place rapidly, instead of having been, as sometimes supposed, a slow continuous process** similar to the rusting of iron or weathering of stone, and to be looked for chiefly in old buildings. Sometimes, after the timber has been partly destroyed, the fungus growth is arrested, leaving sufficient strength to carry the load, and, when the rotted timber is discovered years later, it is assumed that the destruction has been progressing slowly since the erection of the building.

In a case recently examined, the timbers in an old building were found considerably rotted at the bearing ends. Investigation indicated that the rotting occurred and stopped at least twenty-five years ago. In another case, the beams in a weaving mill basement were found seriously rotted at the end of ten years. They were replaced with similar beams of the same material, with the expectation that they would last another ten years at least. Many of these rotted in two years. The living fungus growing on the floor against which they were placed rapidly invaded the new material, which was green and therefore contained sufficient water to make it subject to immediate attack.

The entire frame of a factory in Canada was replaced after three years' service. Nineteen floor beams were removed from a Connecticut mill after two years' service, one beam actually breaking under a light load. The planking of several weaving mill and paper mill roofs has rotted so badly that they were replaced in from nine to fourteen years.

## EFFECT OF HUMIDITY ON THE PROGRESS OF ROT.

Dry rot progresses much faster in summer than in winter in an ordinary building which is heated and thus has its air made relatively dry during the winter months. Moist air gives the condition most favorable for rapid rotting.

**The average relative humidity of a building heated to 60° F.** in winter, without artificial moisture, under conditions of the external atmosphere which have prevailed in Boston for the past ten years, is shown by the following curve. The curve for the summer months is the humidity of the outside air taken from the government records.

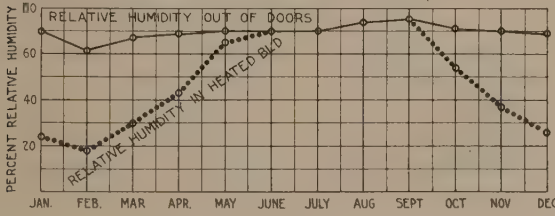


FIGURE 26. GIVING THE AVERAGE RELATIVE HUMIDITY AT BOSTON FOR THE PAST TEN YEARS, BOTH OUT OF DOORS AND INSIDE A BUILDING HEATED TO 60° F. IN WINTER.

If the building is colder than the outside air in summer, or heated to less than 60° F. in winter, the relative humidity will be proportionately higher.

If there is a source of moisture in the building, such as a moist basement, a leaky steam or water pipe, water from drying cloth, paper, or moist cotton, or from artificial humidifiers, the air will be further moistened. These sources of moisture generally act locally, causing a higher relative humidity in one part of the room than another. Near a cold pipe, or a cold roof or wall, the relative humidity may be increased without change in the absolute humidity, that is, the number of grains of moisture in a cubic foot of air. The relative, as well as the absolute humidity, may be locally increased; for example, by a leak in a steam pipe, the presence of a humidifying head, or vapor pot, or a bale of moist cotton. In studying the effect of moisture on dry rot, **one must carefully distinguish between relative humidity and absolute humidity.**

Relative humidity is simply the ratio of complete saturation, or the per cent. of saturation, of the air at the given temperature, while absolute humidity is the actual quantity of water in the air, regardless of temperature. The relative humidity corresponding to a given constant quantity of water in a cubic foot of air changes greatly with the temperature, in other words, warm air will contain a much larger quantity of water than cold air.

The amount of water required for saturation, that is, for a relative humidity of 100% at a barometric pressure of 30 inches, varies with the temperature, as follows:

| 100% Relative Humidity at | | Grains Water per cu. ft. |
|---|---|---|
| 90° F. | approximately | 15 |
| 80° " | " | 11 |
| 70° " | " | 8 |
| 60° " | " | 6 |
| 50° " | " | 4 |
| 40° " | " | 3 |

One gallon of water would produce saturation when distributed through 7740 cubic feet of air, at a temperature of 65° F., equivalent to a room 10 ft. high x 20 ft. wide x 39 ft. long; and a quart of water, in the same volume of air, would give a relative humidity of 25%.

**The relative humidity at any temperature is the percentage which the humidity found bears to that required for saturation.** For example, if air at 70° F. was found to contain four grains per cubic foot, the relative humidity would be 50%, since eight grains are required for saturation at this temperature. Looked at in another way, if external air in December, having an absolute humidity of two grains of water per cubic foot at a temperature of 30° F., is taken into a room heated to 60°, its relative humidity becomes decreased from 100% to 30%, although its absolute humidity remains almost unchanged.

The most convenient and accurate method of measuring relative humidity is by means of a sling hygrometer, which consists of two thermometers held in a suitable frame, so arranged that it can be whirled about rapidly through the air. One thermometer has the bulb enclosed in cloth which is moistened with water. The evaporation of water from this bulb causes a decrease in the temperature which is proportional to the rela-

tive humidity. This quantity can therefore be found by use of tables which accompany the instrument.

Another instrument in common use in cotton mills makes use of the same principle, but the thermometers are fastened to a fixed standard and moisture is continuously supplied to the cloth about the wet bulb by means of a wick from a small bottle of water. **This instrument will indicate too high humidity unless the air is circulated about the wet bulb by fanning or otherwise.** In a measurement recently made with this form of instrument, it indicated 70% as it stood; after vigorous fanning, it indicated 55%.

Neither form of instrument is suited for use in very small spaces, such as the opening about the bearing end of a beam, as the moisture evaporated will in itself change the relative humidity and the circulation necessary for accurate measurement will introduce further disturbance. The instrument best suited for confined situations makes use of the extension and contraction of a hair with the relative humidity. A fair degree of accuracy can apparently be obtained with this instrument if it is calibrated from time to time.

A case recently investigated in a cordage factory, where several strips about 4 ft. wide rotted in the three inch plank flooring the entire length of the factory under spinning machines, which were evaporating considerable quantities of water, shows the effect of locally increased atmospheric humidity. The same form of floor when not in the immediate vicinity of this humidifying process has remained perfectly sound. The average relative humidity in the room is from 50% to 60%, while that directly under the machines is the greater part of the time at nearly 100%.

## DRY ROT AND DAMP ROT.

**Most rot in mill timbers is caused by one or the other of two groups of fungus, one thrives in dampness, the other in air relatively much drier.**

Those belonging to the dry rot group, consisting of the *Merulius lachrymans* and *Coniophora*, have been found in upper floors of reasonably dry mills and are able to thrive with a scant water supply. The dry rot fungi have been particularly destructive to new buildings, and have generally attacked the larger beams of the frame.

The other group which we may designate as damp rot fungi consisting of members of the *Polyporus* family, requires a much larger water supply, and is particularly destructive in poorly ventilated basements. I have found two varieties in several basements, which Mr. C. J. Humphrey, Pathologist in the United States Forest Service, has kindly identified for me.

The *Fomes roseus*, shown in Figures 21 and 22, is pink and covered with small round pores. The pink color is not confined to the surface, but goes through the plant and frequently extends a little way into the wood. Another variety found with great frequency in moist basements is the *Trametes serialis*, which has a tough, white fruiting surface covered with small pores. See Figure 20.

**Undoubtedly the growth of both of these pore fungi can be arrested by moderate drying.** They seem to grow most luxuriantly when the relative humidity is nearly or quite 100%. In a basement recently examined, which was 175 ft. wide with windows on one side only, the relative humidity varied from about 50% near the windows to 100% on the further side, where there was no circulation of air. In the area which was most of the time at about 100%, there was an abundance of fruiting plants of the *Trametes serialis* and *Fomes roseus*. The floor had only been in five years. The spruce planks were completely destroyed, and the yellow pine beams somewhat attacked by the fungus. See Figure 27.

Openings were made in the outside walls and a slight circulation of air obtained, so that the ordinary atmospheric humidity was reduced to about 80% to 90%, with the result that the growth of the fungus was arrested.

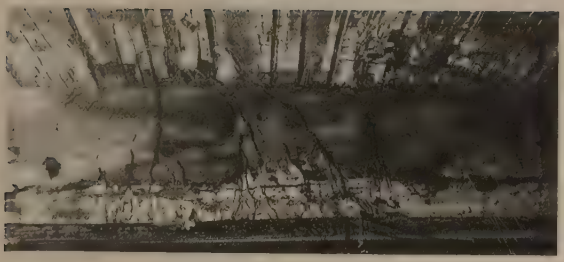

FIGURE 27. 12″ x 16″ YELLOW PINE BEAM AND 4″ SPRUCE FOR PLANK DESTROYED IN FIVE YEARS BY FUNGUS IN A MOIST BASEMENT IN A WOOLEN MILL IN MASSACHUSETTS. SCALE ABOUT ONE-SIXTEENTH NATURAL SIZE.

In another basement where these two varieties were growing luxuriantly, the *Fomes roseus* was found only in the parts which were at practically 100% humidity most of the time. The *Trametes serialis* was found in the drier parts with an atmospheric humidity in the neighborhood of 90% to 95%.

## LOCAL DIFFERENCES IN EXPOSURE TO MOISTURE.

**The relative humidity of air in a room, or basement, sometimes is very different in places only a few feet apart,** and, in studying cases of infection, careful note should be taken of these differences.

An ordinary method of measuring the atmospheric humidity by means of a sling hygrometer gives the average humidity over a considerable space. An example is shown in Figure 28, of locally increased relative humidity.

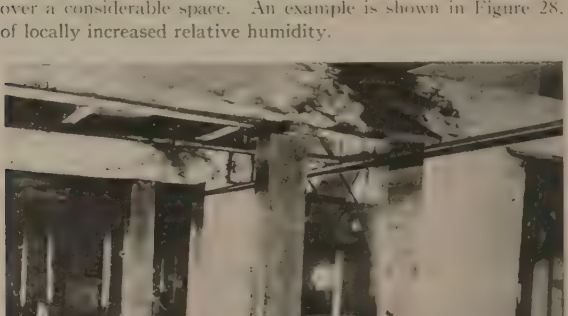

FIGURE 28. FLOOR BEAMS ROTTED OFF BY INCREASED RELATIVE ATMOSPHERIC HUMIDITY CAUSED BY A COLD WATER PIPE.[1]

In this case, a cold water pipe passes under several beams in a basement, the average humidity of which is in the neighborhood of 90%. The lower temperature in the vicinity of this pipe causes an increased saturation up to 100%, at the pipe. The beams directly over it are rotted for a distance of eighteen inches to two feet away from the pipe, as can be seen in the photograph.

1. The distinction between Relative Humidity and Absolute Humidity should be clearly understood. When the term humid or humidity is used in every day talk, *relative* humidity is meant, not absolute. Relative humidity is the percentage of complete saturation that the air happens to contain at the given time and changes with the temperature while the absolute quantity of water per cubic foot of air remains unchanged. The presence of the cold water pipe shown about *increases the relative quantity of the air near it simply by lowering its temperature*, while the number of grains of water in each cubic foot of this air remains almost unchanged.

**Dry and wet are only relative terms.** The degree of dryness is of the greatest importance. The slight difference of a few percent in the relative humidity is sufficient to stop the growth of certain fungi. The growth of the fungus depends **more** upon the relative humidity than upon the number of grains of water per cubic foot. It is also doubtless considerably influenced by the temperature. The effect of saturation of moisture is not limited to the air, but extends to the interior of the timber, as is shown by the rotted tank stave shown in Figure 30.

Weaving room and paper mill roofs are frequently found with a sound shell both inside and out, and the interior entirely rotted away. Sometimes the zone of greatest rotting is nearer the outer roof covering, and sometimes nearer the inside of the building, according to the relative atmospheric humidity.

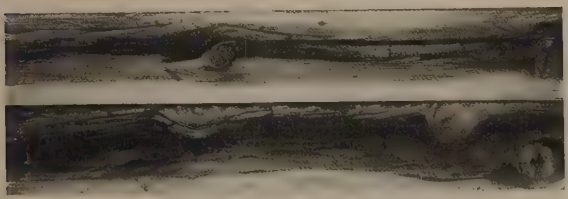

FIGURE 29. EDGES OF TWO SPRUCE PLANKS FROM A WEAVING MILL ROOF SHOWING ROT INSIDE. SCALE ONE-QUARTER NATURAL SIZE.

### Certain processes of manufacture require the atmospheric humidity to be regulated within narrow limits.[1]

If it so happens that this humidity is sufficient to keep the timber or planking near the condition required for the most rapid growth of a common timber destroying fungus, as is frequently the case in weaving and paper mills, exceptional care must be given to selecting a resistant variety of timber, and to giving it a suitable antiseptic treatment in order to prevent serious

1. Cotton carding rooms are frequently maintained at a relative humidity of 50% to 60%, and weave rooms from 60% to 80%. Paper mills are much of the time at nearly 100% in the vicinity of the paper machines or at the ceiling. In many textile processes, the humidity is maintained at a high percentage continuously day and night the year round, the tendency being constantly towards higher humidities and more careful distribution and regulation.

rotting. If, however, conditions of manufacture do not demand high humidity, and it can be kept down to 50% during most of the time, there is little danger of serious rotting of good timber, if it is dry when installed.

It is probable that **a very important factor in the resistance of several woods to fungus is the presence of some moisture resisting material** such as resin, which prevents sufficient water from being absorbed at the ordinary range of atmospheric saturation for the requirements of common fungi. On the other hand, the presence of hygroscopic materials in wood which cause it to absorb larger amounts of water, in order to come into equilibrium with a given atmospheric saturation, would render it more susceptible to attack by fungi.

## EXTREMES OF WETNESS AND DRYNESS BOTH PREVENT ROT.

Figure 30 shows a plank from the bottom of a tank, in which the fungus grew through a narrow space in the middle, the inside next the water being too wet for it and the outside next the air, too dry.

That wood destroying fungi cannot grow under water, or with the wood cells filled with water, is proved by many examples.

One of the fine points in the successful design of wood stave pipe from two feet to ten feet in diameter, for conveying water under pressure, is to design its staves so thin that the pressure will keep the wood saturated; then it will last almost indefinitely without decay.

Penstocks have sometimes been covered with clay to prevent evaporation and keep the cells full of water.

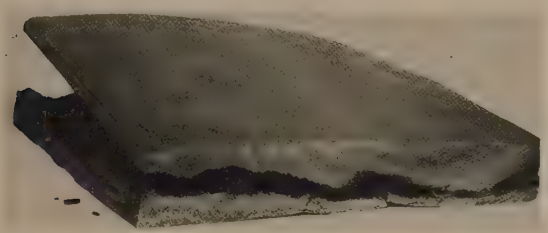

FIGURE 30. 2½" PLANK FROM A WATER TANK.

**Wood of great antiquity has been found buried in clay, in a perfect state of preservation.**[1] Piles under an old London bridge were found sound after being in the water 600 years.[2] The roof beams of the Basilica at Rome were found sound after a thousand years' use under conditions of dryness.[3] In deep test borings for engineering structures, samples of buried logs are brought up in a good state of preservation after burial in wet earth since the glacial epoch.

In popular phrase, "rot comes between wind and water."

1. North American Gymnosperms. Penhallow.
2. Destruction of Wood by Fungi, Buller, Science Progress, Vol. III, No. 2.
3. A Treatise on the Resistance of Materials, D. V. Wood, 1883.

**The weaving rooms of cotton mills are frequently maintained at a saturation of moisture of 70% to 80% during working hours.** With 70% saturation and a temperature of 80° F., a decrease in temperature of 12° at night would cause precipitation, or increase the saturation to 100%. Rot in roof planks and the bearing ends of beams is doubtless chiefly due to this condition. The roof and walls of a manufacturing building are colder than the air in the room for a considerable part of the year, therefore the air in contact with these cooler parts of the structure will be at a higher relative humidity than the average of the room. In the summer months, when these conditions do not hold, the outside humidity is high much of the time, so that *the roof planks and beam ends in a highly humidified mill get little chance to thoroughly dry out at any part of the year*, and antiseptic treatment of the timber is the only certain reliance against decay.

### The Limits of Dampness Required for Growth of Dry Rot Fungus.

Dry rot, or *Merulius lachrymans* fungus, will grow on the surface of wood at atmospheric saturations from 96% to 100%.[1] It will grow inside of large beams of susceptible material at a much lower atmospheric saturation. In one case investigated, the room was maintained at less than 70% relative humidity, yet a large proportion of the beams supporting the second floor were destroyed within two years after the factory was completed.

**A possible source of moisture for supplying the requirements of a fungus growing inside a large beam is the decomposition of the wood itself.** Chemical analysis shows rotted wood to contain less hydrogen and more carbon than the original sound wood,[2] therefore the hydrogen part of the cellulose, or lignine molecule, is more strongly attacked than the carbon part. This would result in the formation of water if the decomposition is accompanied by complete oxidation. Wood undergoing bacterial decomposition under water forms marsh gas in large quantities. This may be formed to some extent when wood rots in the air, but apparently considerable water is also formed as shown by some direct measurements by Dr. Mez.[3] This explains why fungus may thrive for some time in an at-

1. Hausschwammforschungen, Vol. 6, page 308, Moeller, Jena, 1912.
2. Cellulose, Cross and Bevan, 1903, page 239.
3. Der Hausschwamm, Dr. Carl Mez, Dresden, 1908, page 192.

mosphere of lower relative humidity, if established deeply in beams of large size, from the interior of which the water formed by the decomposition of the wood is but slowly evaporated.

In a recent case, fungus appeared on the floor beams under a weave shed, about 300 feet wide, within a year after the building was completed. The beams were about four feet above a damp swampy soil. The builders, appreciating that the conditions were unfavorable, gave the beams a brush treatment with a coal tar preservative, and provided large open windows, at frequent intervals, for ventilation. The beams evidently contained living fungus when received. The ventilation prevented growth of the fungus on the surface of the wood for fifty or sixty feet from the windows. Beyond this, an abundant growth appeared. Measurements showed the relative humidity to be nearly 100% in the middle of the building, and 60% at forty feet from the windows.

**Ventilation Not Always a Cure.**

Ventilation is generally the first preventative measure suggested. Dry wood, which is placed in an atmosphere well below the moisture requirements of a given fungus, is undoubtedly incapable of infection with that fungus; but, ventilation does not necessarily cause drying, as the wood will come into equilibrium with the moisture in the air and will become drier or wetter in proportion to the relative humidity of the air with which it is ventilated. Therefore **timber ventilated with moist air may have its rate of rotting accelerated** rather than retarded. As an example, a thoroughly waterproof covering for a column, which had been completely dried, would be more useful than a hole through the center for ventilation, if this column was used in a moist paper mill.

**Paint Sometimes Retards, Sometimes Accelerates Rotting.**

A heavy coat of paint may accelerate or retard the rate of rotting, depending upon whether it prevents the wood from absorbing or giving up moisture. The condition most commonly met, in which paint causes rotting, is when it is applied to green timbers saturated with water. With dry sound timbers, which are to be placed in a moist atmosphere, a paint will doubtless prove beneficial in proportion to its waterproofing power. "Cold water" or "fireproofing" paints, containing hygroscopic materials, would be expected to accelerate the progress

of rot, because they would attract moisture from the air and increase the moisture in the wood, as in the case of a building in Italy, in which chloride of lime was used as an antiseptic, with the result that the chloride of calcium attracted moisture and caused the rapid destruction of the building by fungus.

**The conditions required for germination and growth of the Merulius lachrymans often have been mysterious.** The spores germinate in an eccentric manner and frequently refuse to grow to fruition on their customary host in artificial cultures. Hartig stated that an alkaline medium is necessary, but it has since been shown by several investigators that an acid medium is required for the growth of the plant. The degree of acidity and the kind of acid is important. Falck shows that acetic, formic or carbonic acids are poisonous to it, while malic, citric and tartaric, in dilute solution, favor its growth.

**Long Life of Dormant Fungi.**

**Dry rot fungi have two methods of reproduction and can remain a long time in a resting state.** The common reproductive body, corresponding to the seed of higher plants, is called a spore, and grows over the surface of the plant. They are of brown color and therefore may be easily distinguished from the surrounding sterile growth, as can be readily seen from Figures 15 and 16. The spores are microscopic in size, being about .0004 of an inch long and .0002 of an inch broad. A single plant produces many millions and their small size allows them to float long distances in the air.

Under unfavorable conditions for growth, such as insufficient moisture, some of these destructive fungi assume a form of reproduction different from that by which they ordinarily spread. In this form, the growing plant separates into small sections which can sprout and grow again when favorable conditions arise. It can remain in this resting state for a considerable time in air dry wood. Some of this dormant fungus is shown in the photo-micrograph, Figure 23.

I have some specimens from a beam which was removed from a mill two years ago. Cultures from time to time show the *Merulius lachrymans*, which it contains, to be still living. Mez[1] mentions a case in which this variety of fungus remained alive for four years and eight months, in a dry museum cabinet.

1. Der Hausschwamm, Dr. Carl Mez. 1908, page 63.

## HOW THE DRY ROT DISEASE IS SPREAD

This disease is chiefly spread by direct contact, but living spores carried in the air can take root when they find a favorable resting place.

Fungi are frequently carried in lumber[1] and spread by placing it in large piles with scant ventilation. As a result of this, beams are often found more deeply infected in the middle than at the ends.

The separation of lumber in the piles by the use of sticks containing living fungus is another fruitful source of infection. Susceptible timber placed on rotten supports near the earth quickly becomes diseased. This is now avoided in several lumber yards by the use of concrete supports as shown in Figure 31.

FIGURE 31. CONCRETE SUPPORTS FOR LUMBER PILES.

1. Bulletin No. 13, U. S. Division of Forestry, page 118.

## HEAT AND DRYING ARE USEFUL IN STOPPING ROT.

**Often an infected building can be sterilized by skilful use of its own heating system.** *Merulius lachrymons* is particularly sensitive to heat, a temperature of 108° F. for three hours, or 115° for one hour, being sufficient to kill it.[1] It is also killed by **complete** dryness.[2] But ordinary air drying does not destroy it.

The particular varieties of fungi that destroy roof planks are undoubtedly more sensitive to dryness and less sensitive to heat than dry rot. It is therefore probable that heating a weave shed or paper mill roof will have little beneficial effect unless it is infected with *lachrymans* or *Coniophora*.

**Heat as a means of destroying lachrymans and Coniophora in mill beams was tried** recently, at the suggestion of the writer, on a large mill, in Canada, which was badly infected throughout; but, later, it was found that the disease had already progressed so far before the heating was applied that the structure had become unsafe, therefore the beams had to be replaced. This removal of a thousand beams and columns gave an excellent opportunity to test the efficiency of the previous heat treatment by cultivating samples from those beams in which the infection was the deepest. This treatment had comprised heating the mill four times, to about 115° F., by use of the steam heating system in warm weather, from Saturday noon until Monday morning, the temperature being carefully regulated by use of thermometers placed at the ceiling.

In applying this heat treatment in mills protected against fire by automatic sprinklers, care must be used not to open or permanently injure the sprinkler heads. The temperature of the air should be kept 50° below the melting point of their fusible solder, which ordinarily is about 165°.

Specimens were cultivated from forty of the badly rotted beams and *only four showed living fungus*. One hundred and three beams removed and left on the ground for several months

1. Hausschwammforschungen, Vol. 1.
2. Hausschwammforschungen, Vol. 6.

were examined superficially, and, in all of these, *only six* showed suspicious threadlike growths. The window frames and hollow roof were not sterilized by this treatment. Some of the few living cultures found came from the ends of beams which were imbedded in the brickwork where the heat could not readily penetrate, and some of the beams left on the ground may have become reinfected.

On the other hand, beams removed from the mill before it was heat-treated showed a vigorous growth of fungus on cultivation, and also the formation of normal fruiting plants when left lying in the yard.

While the results of this one practical experiment are not absolutely conclusive, they are very encouraging and indicate that **the small cost of putting steam on the heating coils is well worth trying, if there is any suspicion of dry rot in a new building.**

FIGURE 32. THREADLIKE STERILE FUNGUS PLANT ON END OF A ROTTED MILL BEAM. SCALE ONE-QUARTER NATURAL SIZE.

Heating will probably prove more efficient in the few scattered superficial infections of a mill just completed than it did in this mill where the growth had been in active progress for two years or more and had deeply penetrated the susceptible material.

The special heating will also increase the rapidity of drying and thereby tend to limit the spread of the disease through the agency of the rapidly growing threadlike plants. These growths pass rapidly along the splines of moist floor planks and through holes in moist columns, or openings between double beams, and can thereby quickly reach most of the susceptible material in the building. The most serious cases of rapid spread of the dry rot fungus that I have yet investigated have occurred where sappy or non-resistant material, exposed to the weather, remained in a water-soaked condition until it was covered, so that it could not dry out. The drying will also arrest other varieties of fungi than the *lachrymans*.

## HOLES IN COLUMNS AND DOUBLE BEAMS WILL NOT PREVENT ROT.

**One of the reasons given for bored columns and double beams had been to prevent dry rot,** and considerable importance has sometimes been given to this feature.[1]

Undoubtedly columns with holes through them, and thinner beams, would dry out quicker if given a chance to season, but the common custom of boring green or wet columns just before they are put in place in the building, and using moist lumber for double beams, *leaves ideal places for the growth of fungus*, as the air in the openings may be nearly saturated with moisture. The holes in the columns have the additional objection of forming a convenient passageway for the fungus to pass rapidly from floor to floor before the building has dried out.

Untreated Carolina pine used for interflooring sometimes serves not only to infect the mill, but to carry the infection to all susceptible beams or planking in the floor.

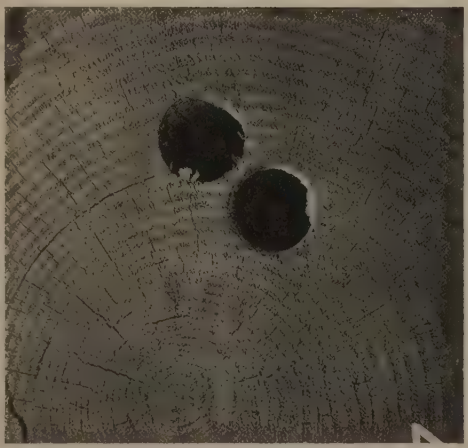

FIGURE 33. CENTRAL CROSS SECTION OF 10″ x 10″ SOUTHERN PINE COLUMN BORED FROM OPPOSITE ENDS. HOLES DO NOT COME TOGETHER IN CENTER AND FUNGUS CAN BE SEEN IN EACH HOLE.

1. Engineering News, Vol. 62, 1909, page 620.

FIGURE 34. 10″ x 10″ COLUMN, SHOWN IN CROSS SECTION IN FIGURE 33, SPLIT THROUGH THE HOLES, SHOWING THE FUNGUS INSIDE THEM MORE CLEARLY. THE HOLES ARE ONE AND ONE-HALF INCHES IN DIAMETER.

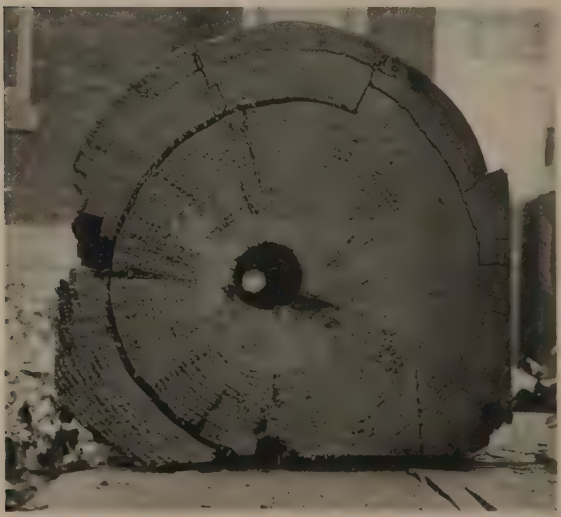

FIGURE 35. CROSS SECTION IN CENTER OF A 10″ x 10″ LOBLOLLY PINE COLUMN, BADLY ROTTED, IN A COTTON FACTORY AFTER THREE YEARS' SERVICE. NOTE THAT THE HOLE THROUGH THIS COLUMN DID NOT PREVENT IT FROM ROTTING.

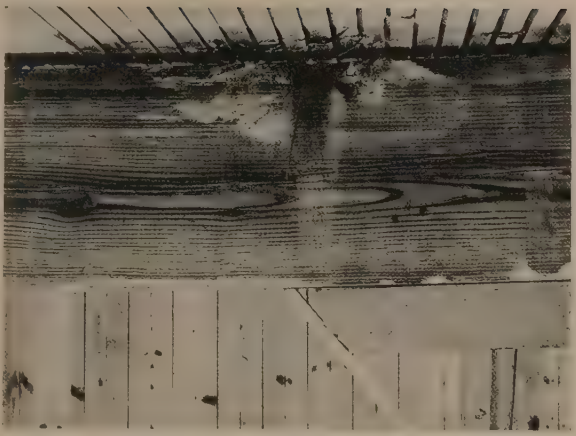

FIGURE 36. FRONT BEAM OF A PAIR OF DOUBLE 8″ x 18″ BEAMS HAS BEEN REMOVED, SHOWING DRY ROT FUNGUS GROWING IN THE SPACE BETWEEN THE BEAMS.

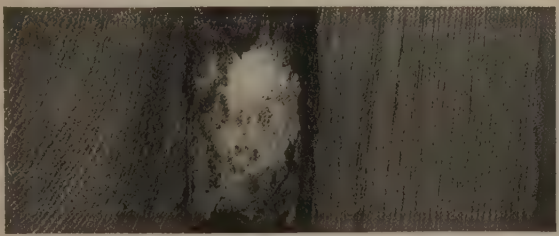

FIGURE 37. DRY ROT FUNGUS GROWING ALONG HOLE BORED IN OAK COLUMN. SCALE ABOUT ONE-THIRD NATURAL SIZE.

## SLOW BURNING CONSTRUCTION.

The following drawings show two examples of slow burning factory construction which are in common use. One, a several story building of moderate width; the other, a one story building which may have any width, as it is lighted by means of windows in the sawtooth roof. The basement of the latter form of construction gives trouble from rotting timber if the building is located on moist ground, owing to the fact that it is practicably impossible to get a natural circulation of air through this basement in the widths of 200′ or more, commonly used in weaving mills.

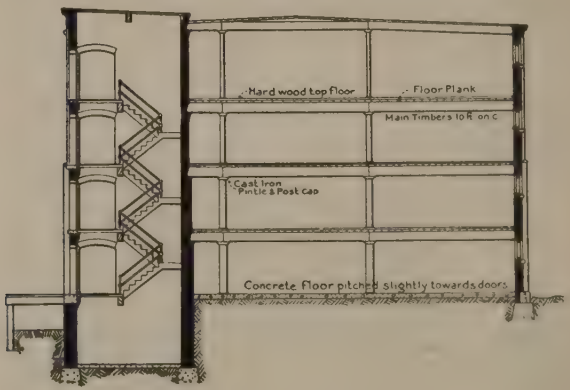
Hard wood top floor
Floor Plank
Main Timbers 10 ft. on c.
Cast Iron Pintle & Post Cap
Concrete floor pitched slightly towards doors

FIGURE 38. STANDARD FORM OF SLOW BURNING MILL CONSTRUCTION, WITH BEAMS SPACED FROM 8 FT. TO 12 FT. ON CENTERS, AND HEAVY PLANK FLOORS.

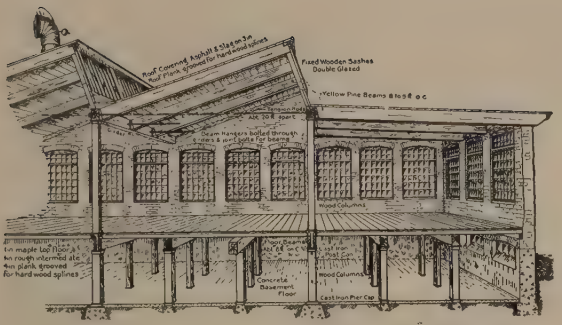
Roof Covering Asphalt 4 Slag on 3/4" Roof Plank, grooved for hardwood splines
Fixed Wooden Sashes Double Glazed
Yellow Pine Beams 8 to 8 o.c.
Wood Columns
Wood Columns
Concrete Basement Floor
Cast Iron Pier Cap

FIGURE 39. STANDARD SLOW BURNING FACTORY BUILDING WITH SAWTOOTH ROOF SUCH AS IS FREQUENTLY USED FOR WEAVING MILLS.

**Laminated Floor.**

In slow-burning timber construction, it has been customary in many cases where an unusually stiff floor is required, to use 2″ x 4″ or 3″ x 6″ planks, spiked together on edge, for forming the floors. **This so-called laminated construction is very treacherous as far as rotting is concerned, particularly if the planks are not thoroughly dry when the building is covered in.** In buildings several stories high, it is customary to lay the plank of the lower floors before the walls of the upper stories are complete, thus leaving them exposed to the weather until the roof is put on. Sometimes the floors become thoroughly water-soaked by means of the numerous cracks between the planks. The evaporation of this water is retarded by the great thickness of the floor thus formed of plank on edge and by the top flooring. This moisture encourages rotting. In storehouses, for which this form of floor is frequently used, the conditions are worse than in the manufacturing rooms, because the storehouses are seldom artificially warmed in winter, thereby giving less opportunity for drying. Several such

cases have been reported within the last few months. The following figure shows two pieces, 3″ x 6″ x 24″, cut from some Southern pine planks from such a floor in a Chicago storehouse, after six years of service. These floors were water-soaked by rains before the roof was put on, and, as the building was not heated, the process of drying out was very slow, with the result that the floors throughout the entire building were considerably rotted.

FIGURE 40. PIECES CUT FROM 3″ x 6″ SOUTHERN PINE PLANKS REMOVED FROM THE LAMINATED FLOOR OF A CHICAGO STOREHOUSE AFTER SIX YEARS' SERVICE.

## VARIETIES OF TIMBER AVAILABLE.

**The different varieties of timber available for mill construction are fewer in number than those available for railroad ties,** or for structural purposes requiring smaller or shorter pieces. At present, the material in almost universal use for columns and beams in factories of "slow-burning" type, in the United States, east of the Rocky Mountains, is Southern pine.

Occasionally hemlock or spruce is used for columns of the smaller sizes. In the older mills, columns of white pine and oak are often to be found.

Spruce and hemlock are frequently used for floor and roof planking. Indeed, until recently, spruce plank was the favorite floor material for New England mills.

Douglas fir is occasionally used for columns, beams and floor plank in the Middle West and will probably be more used in the future. The greatest manufacturing districts of the country are within convenient reach of the Southern pine forests and Southern pine is undoubtedly used in much larger quantities than all other varieties, spruce plank being next, and hemlock, third. Therefore, careful study of the Southern pines is of the greatest importance.

### Cheapness As An Index of Quality.

**It is a significant fact that much of the best longleaf pine timber produced in the South is being shipped to Europe.** The European buyers consider quality first and are willing to pay a higher price for good timber. Too many of the American buyers of mill timber are chiefly guided by price. Several lumber manufacturers, producing excellent longleaf pine timber, stated that they hardly considered it worth while to quote on true longleaf timber to the American trade, as mixed varieties, offered at a lower price, were practically certain to be accepted.

Longleaf pine of merchantable inspection, Interstate Rules of 1905, in sizes suitable for mill timber, can be had at the present time, I am told, at about $33 per M, delivered in New England. "Prime" grade would cost about three dollars more. The best quality "German Prime" would cost from $40 to $50.

## COMMON VARIETIES OF SOUTHERN PINE

**There is much confusion in local names.** Mohr gives six Latin and twenty-nine common names as having been used at different times, or different places, for the longleaf pine; and, the other varieties of pine have nearly as many. The Cuban and longleaf pines are sometimes confused as both have long leaves, while the shortleaf and North Carolina both have shorter leaves.

**The positive identification of longleaf pine lumber is difficult or impossible.**[1] There are slight microscopic differences in the form of the medullary rays of the North Carolina pine, as given by Penhallow[2] and Roth,[3] but to use them for identification would require considerable experience in the microscopic study of the pines. The macroscopic differences are more striking with characteristic specimens. The longleaf pine is heavy, resinous and fine grained, averaging for the dry wood from the butt of the tree, according to Sargent, 43.7 lbs. per cubic foot. See Figures 42 and 46.

The Cuban pine is slightly heavier, averaging 47 lbs. per cubic foot, resinous and coarse grained, with a large proportion of dense summerwood, and a much larger proportion of sapwood.

The North Carolina pine, also known as loblolly pine and frequently sold as shortleaf pine, is lighter, averaging 34 lbs. per cubic foot, somewhat less resinous, coarse grained, with a large percentage of sapwood. See Figures 41 and 44.

1. Mr. Arthur Koehler, Expert in Wood Identification of the U. S. Forest Products Laboratory of Madison, Wis., states, in a personal communication, that recent discoveries which he has made, and which will be published by the U. S. Forest Service in the near future, make it possible to always distinguish longleaf pine from shortleaf and loblolly, by the gross character in large pieces, and microscopically in small specimens.

2. North American Gymnosperms, D. P. Penhallow, 1907.

3. Bulletin No. 13, U. S. Division of Forestry, 1897.

The shortleaf pine is moderately light, averaging 38 lbs. per cubic foot, the least resinous of the four, and of medium grain. See Figures 43 and 45.

The following are the weights per cubic foot given by Mohr[1] for kiln dried material, — longleaf 36 lbs., Cuban 37 lbs., shortleaf 30 lbs., and North Carolina 31 lbs. The reason for Mohr's weights being less than those of Sargent is that he takes the average of the tree, the top of which is much lighter, while Sargent considers only the heartwood at the butt. Mohr's weights are probably much nearer to the average timber now on the market than Sargent's.

1. Bulletin No. 13, U. S. Division of Forestry.

FIGURE 41. LOBLOLLY OR NORTH CAROLINA PINE. (*Pinus taeda.*)

Rosin at A 14.6 %, B 1.6 %, C 3.1 %.
Density at A 26.3, B 26.8, C 27.9 lbs. per cu. ft.
A, Heartwood; B and C, Sapwood.

Note the characteristic broad sapwood and dark grain bands, less clearly marked than those of the longleaf.

FIGURE 42. LONGLEAF PINE LOG 29″ IN DIAMETER. (*Pinus palustris.*)

Note dark colored, well marked heartwood and comparatively thin sapwood, also fine grain bands with dark colored summerwood. The resinous quality of the wood is indicated by the dark color.

FIGURE 43. SHORTLEAF PINE. (*Pinus echinata.*)

Rosin at A 23.3%, B 5.2%, C 4.4%, D 1.8%, E 2.3%.
Density at A 33.7, D 32.5, E 31.1 lbs. per cu. ft.
A, B, C, D, Heartwood; E, Sapwood.

This wood is generally somewhat lighter in color, and less resinous in appearance than the longleaf. The dark summerwood in the grain bands is also not quite so clearly marked.

FIGURE 44. LOBLOLLY OR NORTH CAROLINA PINE (*Pinus taeda.*)
Rosin at B 1.9 %, Density 26.5 lbs. per cu. ft., Sapwood.

Note the characteristic broad sapwood and dark grain bands, somewhat less clearly marked than those of the shortleaf.

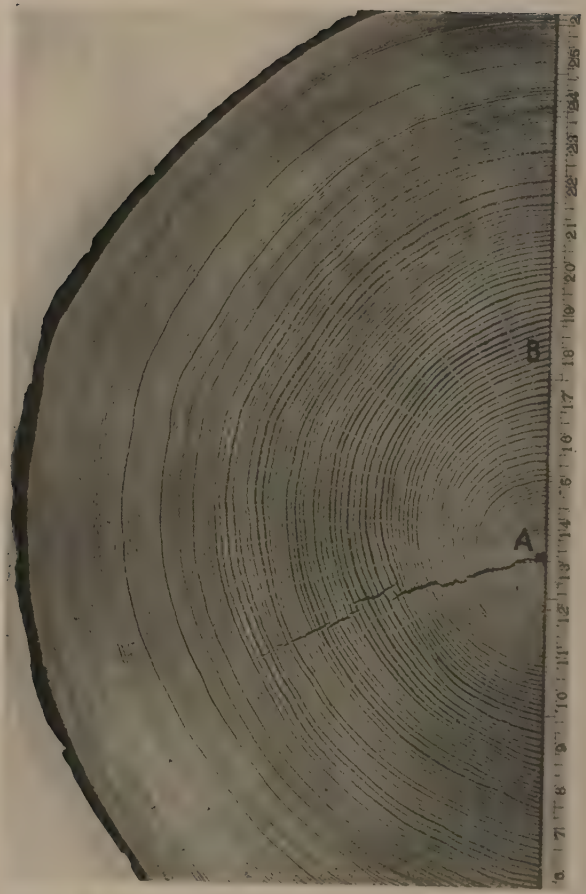


FIGURE 45. SHORTLEAF PINE *Pinus echinata*.
Rosin at A 4.6%, B 1.6%. Density at A 30.6, B 29.1 lbs. per cu. ft.

Note that the wood is generally somewhat lighter in color, and less resinous in appearance than the longleaf. The dark summerwood in the grain bands is also not quite so clearly marked.

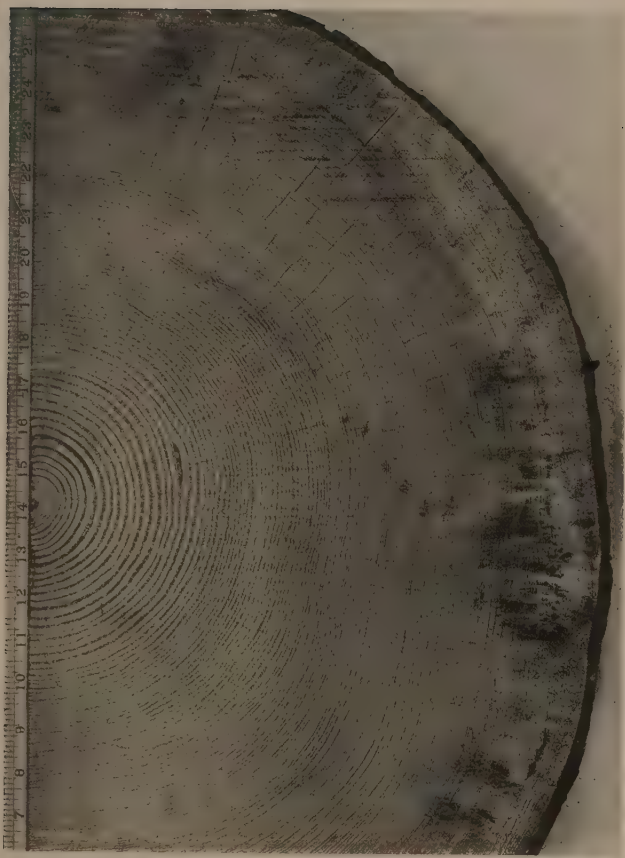

FIGURE 46. LONGLEAF PINE LOG 28″ IN DIAMETER. (*Pinus palustris.*)

Note the dark colored, well marked heartwood and the comparatively thin sapwood, averaging about 2¾″ in thickness. This timber, while undoubtedly longleaf pine, is inferior to that shown in Figure 42, as it is lighter in weight, less resinous and more subject to decay, as shown by the fact that within a year after it was cut, rotting had started in the outer portions of the heartwood, although both sections were kept under identical conditions.

## AVAILABLE SOUTHERN PINE.

In some recent printed discussions,[1] it is intimated that if the requirements of the purchaser are clearly made known to the lumber manufacturer, and he is willing to pay the price, as good pine timber can be obtained now as in the past. As an illustration of the practical conditions, we may cite a recent case. The president of a paper mill, requiring plank for a new roof, wrote at our suggestion to a large yellow pine lumber manufacturing company, known to be cutting good longleaf pine at some of its mills. **He stated clearly that he required good resinous longleaf plank for a paper mill roof and accepted the price named without question.** The following photographs, Figure 47, show twelve of the planks received.

The following table shows the wide variation in two of the most important qualities that determine strength and resistance of decay.

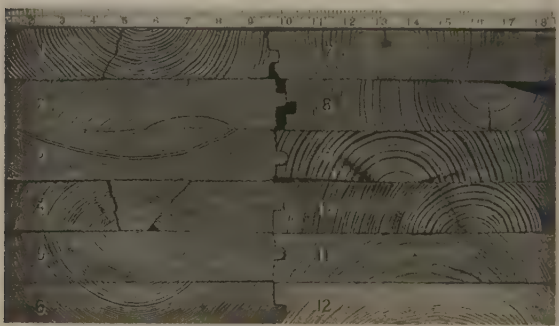

FIGURE 47. PINE PLANK FOR A PAPER MILL ROOF. SCALE ABOUT ONE-SIXTH NATURAL SIZE.

| Density | Rosin | Density | Rosin |
|---|---|---|---|
| 1.42 lbs. per cu. ft. | 5.6% | 7.26 lbs. per cu. ft. | 3.0% |
| 2.33 " " " " | 2.5% | 8.35 " " " " | 1.2% |
| 3.28 " " " " | 1.8% | 9.40 " " " " | 7.9% |
| 4.41 " " " " | 2.4% | 10.47 " " " " | 2.8% |
| 5.38 " " " " | 6.2% | 11.31 " " " " | 1.6% |
| 6.42 " " " " | 6.9% | 12.31 " " " " | 2.3% |

1. Proceedings of the American Society for Testing Materials, 1914, Part 1, page 385.

These samples fairly represent the entire lot, and **they vary in density from 26 to 47 pounds, per cubic foot,** and the rosin content varies from 1.8% to 7.9%. The lumber manufacturer states that this is a fair average of the longleaf pine, "all heart" grade, now being shipped under the present grading rules.

It is generally agreed, I think, by lumber experts, that there are few purposes for which lumber of this wide range of density will be equally serviceable. It is probably **all** longleaf pine, but some of it is **poor** longleaf pine.

**This shows clearly the need of a system of grading, by which the heavy resinous material can be separated from that which is light** and porous, and each applied to its proper use, suitable antiseptic treatment being given to the lighter material if the use requires resistance to decay.

With this separation, *all of it is more valuable than the mixture* now being sold.

In a recent discussion,[1] it was stated by Mr. Howard F. Weiss, Director of the United States Forest Products Laboratory, that there is no difference between the longleaf pine now growing in the South and that which grew in past years. This is doubtless true. Later, in the same article, is the following, — "A number of other woods are now apparently being mixed with the Southern pines and are sold with them apparently without distinction. In this laboratory we have received Norway pine on contracts in which we called for longleaf pine."

Mr. Knight C. Richmond,[2] in a recent discussion before the National Association of Cotton Manufacturers, makes the following statement. "One or two cases have come to my mind which show the limit to which this has been carried. In one case a vessel sailing from Portland, Oregon, loaded with Oregon fir in large sized sticks, sailed around to Boston harbor and the Oregon fir was sold to a lumber dealer, who promptly sent it over to a firm of contracting engineers under the specification of longleaf Georgia pine, and got away with it.

One other case, which seems almost incredible, was a shipload of spruce[3] sent down to Boston and then shipped back to the mill to build flumes with in a paper mill where they wanted a particularly good lot of Georgia longleaf yellow pine."

1. Engineering Record, Jan. 12, 1914.
2. Transactions at the National Association of Cotton Manufacturers, Vol. 96, April, 1914, page 283.
3. This word was printed "cypress" in the printed discussion. Mr. Richmond states that this is an error, that it should be "spruce."

*The present definition for longleaf pine of the American Society for Testing Materials opens the way to such practices by giving a double meaning to the name "longleaf pine."* So far as the present definitions of the American Society for Testing Materials go, almost any kind of wood, shortleaf, Cuban or North Carolina, can be sold under them as "commercial longleaf pine."

In the first edition of this pamphlet, I quoted some figures of prices which had recently been paid for Southern pine timber, and drew the conclusion that selected, uniformly resinous longleaf pine would probably cost $115. per thousand. These figures were ridiculed by lumber experts, attention being called to the prices quoted in the open market for **"commercial** longleaf pine" timber. **"Commercial** longleaf pine" may, or may not, be **true** longleaf pine, and is not necessarily sufficiently resinous to resist decay, or sufficiently dense to give the desired strength.

It has not been possible to check the above mentioned estimate, because it has not been possible to get quotations on, or to buy, such excellently uniform and carefully selected material as that described. Therefore this question of price must remain open until such material is found available in quantity, under ordinary commercial conditions.

(1) This definition reads:—

"Southern Yellow Pine." Under this heading two classes of timber are used, (a) Longleaf Pine, (b) Shortleaf Pine.

It is understood that these two terms are descriptive of quality rather than of botanical species. Thus, shortleaf pine would cover such species as are now known as North Carolina pine, loblolly pine, and shortleaf pine. "Longleaf Pine" is descriptive of quality, and if Cuban, shortleaf or loblolly pine is grown under such conditions that it produces a large percentage of hard summerwood, so as to be equivalent to the wood produced by the true longleaf, it would be covered by the term "Longleaf Pine."

## ROSIN AS A CAUSE OF RESISTANCE OF WOOD TO FUNGI.

The causes of natural resistance to fungi in wood are obscure and have been investigated but little. Tannins in moderate concentration oppose the growth of *Merulius lachrymans* as shown by Wehmer.[1] He finds, however, that they offer less hindrance to the *Coniophora*. The *Daedalea quercina*, on the other hand, thrives on tannin-rich woods; but this last named fungus has not been found important as a destroyer of structural timber, other than posts exposed to the weather. Moreover, woods containing much tannin are now little used for mill construction.

### Heartwood is Generally Much More Resistant to Fungi than Sapwood.

The process of heart formation in trees is little known. In the Southern pines it generally takes from twenty-five to fifty years and is frequently attended with increase in the rosin. The photographic activity mentioned on Page 71 is much more noticeable in the heart than the sapwood of many trees, including the hard pines. In some of the oaks and locust, the tannin increases sharply at the line where the heartwood commences. The presence of starches and sugars in the sapwood, which serve as foods for fungi, as well as the greater water content of this part of the tree, is probably the chief cause of its more rapid destruction, while the resistance to water of the heart rosin and the antiseptic action of tannin are undoubtedly important factors in the resistance of the heartwood.

**The preservative power of rosin is frequently mentioned as a matter of general observation**, but careful study into the cause has not been made. Penhallow[2] mentions it. Mayr[3] has analyzed many of the pines for rosin and shows some interesting facts in regard to its distribution in different parts of the tree, but he is guarded in his conclusions, being rather inclined to attribute the durability of pine heartwood to material which he calls "dauer stoff," in German, of which the nearest English equivalent is "durable material," and which he associated with the dark color of heartwood.

1. Wehmer, Mycologisches Centralblatt, Vol. 1, 1912, pages 138 and 166. Vol. 2, page 331.
2. Penhallow, North American Gymnosperms, page 162.
3. Mayr, Harz der Nadelholzer, 1899, pages 43-49.

Mayr's analyses tend to throw some light on observations of Hartig on the relative resistance to *lachrymans* of the heart and sapwood of *Pinus sylvestris* (Scotch fir), and *Picia excelsa* (Norway spruce), both European woods. Hartig[1] finds that the sapwood of the *Pinus sylvestris* is attacked by *lachrymans* more rapidly than the heartwood, while the reverse is true with the *Picia excelsa*, as shown by the following figures, giving the average loss in weight of specimens infected with *lachrymans* and allowed to rot in contact with ashes, sand, coal dust, chips, etc.

**Percentage Loss of Weight by Rotting in Relation to Rosin Content.**

| | Pinus Sylvestris. | | Picia Excelsa. | |
|---|---|---|---|---|
| | Heart. | Sap. | Heart. | Sap. |
| Dry Winter cut wood, lost in weight, | 7.2% | 16.6% | 12.8% | 9.8% |
| Moist Winter cut wood, lost in weight, | 5.6 | 16.4 | 29.9 | 14.9 |
| Moist Summer cut wood, lost in weight, | 6.8 | 14.9 | 24.0 | 22.0 |
| Average percentage loss in weight, | 6.5 | 16.0 | 22.2 | 15.5 |
| Average percentage of rosin from Mayr's analyses, | 4.5 | 3.0 | 1.05 | 1.68 |

Note that with only 1.05% of rosin the loss was 22.2%, while with 4.5% of rosin the loss was 6.5%, these two being for heart wood, while for sapwood the difference was not large.

**The inverse ratio of the loss of weight to the percentage of rosin is in as close agreement as could be expected** for quantities varying between such broad limits as the percentage of rosin in these woods.

An experiment was made by the writer in which longleaf pine heartwood, out of which the rosin had been dissolved with benzole, was infected with *Merulius lacrymans*, together with a specimen of the original unextracted wood. After one year's exposure of each, the wood from which the rosin had been extracted was reduced in weight four times as much as the original wood, indicating that the rosin exerted a decided preservative action.

1. R. Hartig. Der Echte Hausschwamm, 1902, page 44.

**In some of the pines, there is an abrupt increase in the rosin content at the line between sap and heart,** as there is of the tannins, similarly, in some of the oaks[1] and locust. There is also an abrupt change in the light-sensitive property of heartwood, which is associated with its dark color in some cases, but not always.

The following rosin analyses of longleaf pine are given by the United States Forest Service.[2]

Rosin Analyses.

| | 23 ft. from Ground. | | | 33 ft. from Ground. | | |
|---|---|---|---|---|---|---|
| **No. of trees** | **Sap** | **Outer heart** | **Inner heart** | **Sap** | **Outer heart** | **Inner heart** |
| 4 | 1.48% | 6.78% | 4.97% | 1.93% | 4.80% | 2.97% |
| 3 | 1.76 | | 4.06 | 1.35 | | 4.29 |
| 3 | 1.74 | 4.35 | 6.29 | | | |
| 4 | 1.78 | | 4.95 | | | |
| 3 | 1.49 | 3.48 | 2.47 | 1.34 | 3.63 | 2.79 |
| Average rosin in heartwood | | 4.67% | | | 3.70% | |

The following pages show some representative tests made by the author, to determine the rosin content and density of longleaf pine from several different places.

1. G. Kraus, Physiologie fes Gerbstoff, pages 128-129.
2. Bulletin No. 8, Division of Forestry, 1893, page 49.

## LONGLEAF PINE FROM THE FOOT-HILLS OF ALABAMA

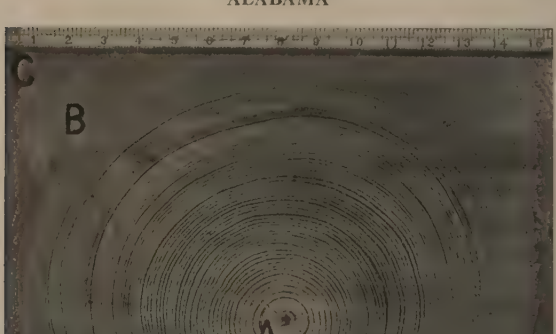


FIGURE 48. 12" x 16" LONGLEAF PINE FROM TOP OF TREE.
Rosin at A 14.2%, B 1.8%, C 3.2%.
Density at A 29.2, B 29.3, C 25.0 lbs. per cu. ft.

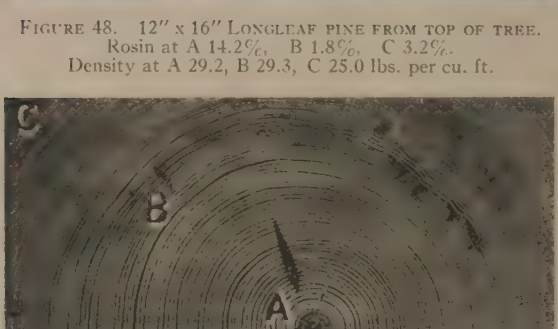


FIGURE 49. 12" x 16" LONGLEAF PINE FROM BUTT OF TREE.
Rosin at A 13.6%, B 13.8%, C 9.8%.
Density at A 31.0, B 33.7, C 28.4 lbs. per cu. ft., the average percentage of rosin at the butt being about twice that at the top.

## LONGLEAF PINE FROM THE FOOT-HILLS OF ALABAMA

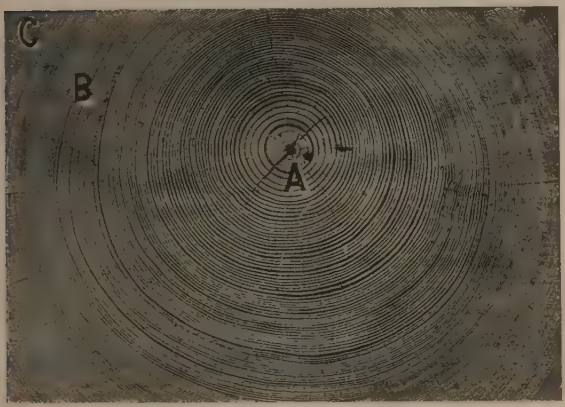


FIGURE 50. 12″ x 16″ LONGLEAF PINE FROM TOP OF TREE. Rosin at A 9.6%, B 1.5 %, C 2.7%. Density at A 27.5, B 35.0, C 27.8 lbs. per cu. ft.

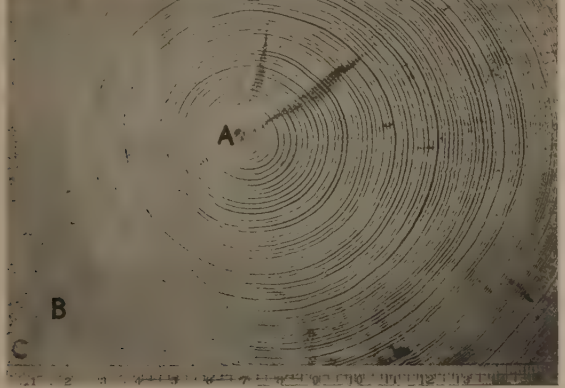


FIGURE 51. 12″ x 16″ LONGLEAF PINE FROM BUTT OF TREE. Rosin at A 25.7%, B 10.7%, C 8.5%. Density at A 37.0, B 35.5, C 33.0 lbs. per cu. ft., the average rosin at the butt being about three times that at the top.

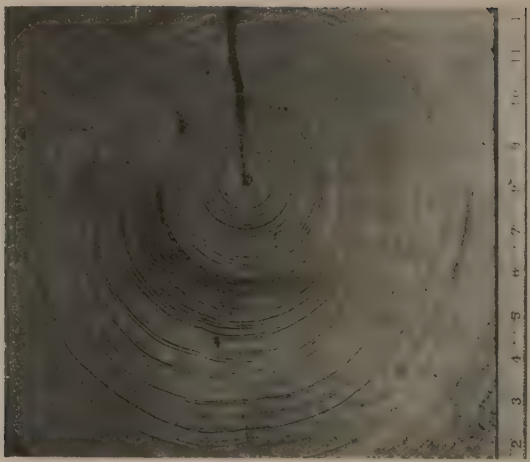

FIGURE 52. LONGLEAF PINE FROM CENTRAL MISSISSIPPI. SECTION CUT FROM TREE 42′ FROM GROUND.

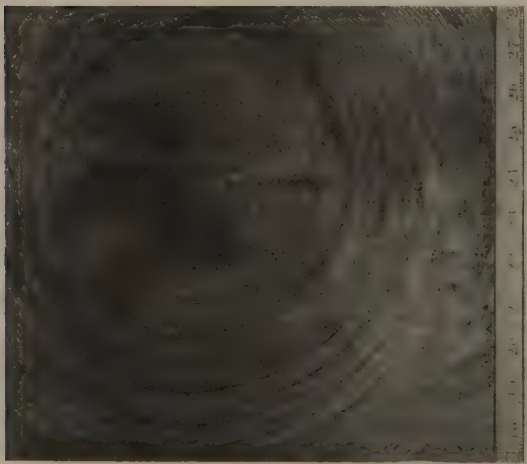

FIGURE 53. LONGLEAF PINE FROM CENTRAL MISSISSIPPI. SECTION FROM BUTT OF SAME TREE.

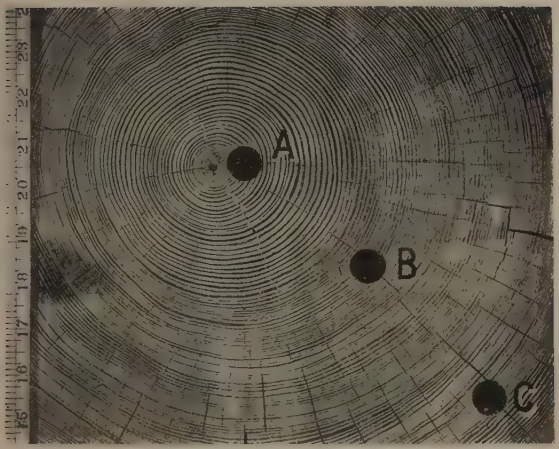


FIGURE 54. LONGLEAF PINE FROM COASTAL PLAIN OF LOUISIANA. Rosin at A 1.2%, B 10.8%, C 5.0%.
Density at A 36.3, B 39.3, C 32.0 lbs. per cu. ft.

FIGURE 55. LONGLEAF PINE FROM COASTAL PLAIN OF LOUISIANA. Rosin at A 6.0%, B 17.2 %, C2.8%.
Density at A 29.4, B 34.1, C 25.7 lbs. per cu. ft.

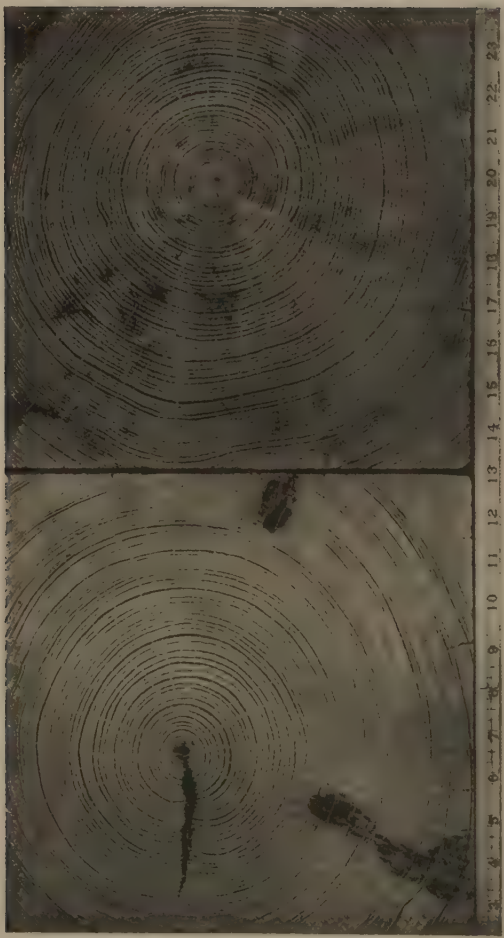

FIGURE 56. RESINOUS LONGLEAF PINE FROM TEXAS.

**The longleaf pine heartwood shows a wide variation in the rosin content,** as can be seen from the several analyses given. It is evident that the top of the tree is generally less resinous than the butt, although this is not a universal rule. This would indicate that the only generalizations which can be made as to the durability of longleaf pine, as indexed by rosin, are that the **average longleaf pine is more resinous** than the average wood of the shortleaf and loblolly, and, in the longleaf heartwood, the resin is generally more uniformly distributed. The **light non-resinous longleaf** pine from the tops of trees, or from trees which have grown under unfavorable conditions, doubtless is **no more resistant to decay than similar non-resinous shortleaf.**

The following statement is taken from a recent German work entitled "Hausschwammforschungen" (or House Fungus Investigation), Vol. 3, page 178.

"All wood destroying fungi attack coarse grained Scotch fir sapwood more readily than resin rich dense material. The Scotch fir heartwood under natural conditions is attacked with great difficulty even by *Merulius domesticus*, particularly in small cultures. Resin rich knots are practically immune."

**The rosin doubtless owes its antiseptic power chiefly to waterproofing qualities,** preventing the progress of fungi by causing the wood to come into equilibrium with the average moisture of the air without sufficient water for their growth. Besides being present in the sapwoods of most of the pines in smaller quantities than in the heartwood, it is associated in the green sapwood with hygroscopic substances which annul its waterproofing action to a certain extent.

**Under the present system of grading and selection of Southern pine timber, the chief guarantee of durability is the proportion of heartwood.** This is undoubtedly a sufficient guarantee for dry locations, if the timber itself has been well dried before it is put into the structure. **Southern pine timber in a moist atmosphere cannot be depended upon, however, unless its durability is assured by a high percentage of rosin, or is reinforced by antiseptic treatment,** or, preferably, both.

Natural resistant woods, owing their durability to substances uniformly distributed in the tree, would be expected to be

superior to chemically treated wood, if the antiseptic material is sufficiently active for the conditions under which the wood is to be used.

**The percentage of rosin in the sound centers of rotted beams taken from a mill was determined in order to get an idea of the amount at which the fungus would not grow** under ordinary mill conditions. See Fig. 57.

In the poorest of hard pine, there is generally a sound center to rotted beams and this center contains more rosin than the remainder of the section. Sometimes it is not bounded by the growth rings but is very irregular, the cause being that rosin has been irregularly deposited in the section, owing to knots or injuries to the tree. The limits of the sound center are not always the same as those of the heartwood. There is sometimes a much greater deposit of rosin at the center of growth than in the older wood. In some of the shortleaf pines this peculiarity is conspicuous. See Figure 43.

**It is apparent that the limiting amounts of rosin which is just sufficient to stop the fungus is in the neighborhood of three per cent.**

The limiting power of rosin is undoubtedly not absolute, but varies with the moisture, variety of fungus, and time of exposure. Therefore, it is safe to assume that a mill beam should have four or five per cent of rosin throughout, to successfully withstand fungus by its own power of resistance under ordinary conditions of dampness. Dye houses and paper mills would probably require more.

Both the rosin content and the density can be conveniently measured by boring one inch holes 2" deep into the end of the beam, collecting the chips, drying and weighing them, then extracting the rosin from them with benzole, and weighing it.

The boring should be done with a bit, without a spur, which cuts a smooth hole with a flat bottom and can therefore be easily measured. A hole one inch in diameter and two inches deep will have a cubical contents of .00091 cu. ft.

The rosin extraction can be made most conveniently by means of carefully distilled benzole and a Soxhlet extraction apparatus. The drying can be accomplished in an oven maintained at a temperature of 212° F. by water, electricity or other form of

heat and should be continued until the specimen no longer loses weight. A chemical balance which is sensitive to one milligram should be used in the weighing. The specimens should be kept after being dried, until they are weighed, in desiccators with suitable drying agents such as strong sulphuric acid or calcium chloride.

Cuban or North Carolina pine with 10% of rosin is apparently as resistant to fungus as longleaf pine with the same percentage. Heart without rosin is not immune.

ROTTED 12″ x 16″ PINE BEAMS REMOVED AFTER TWO YEARS' SERVICE.

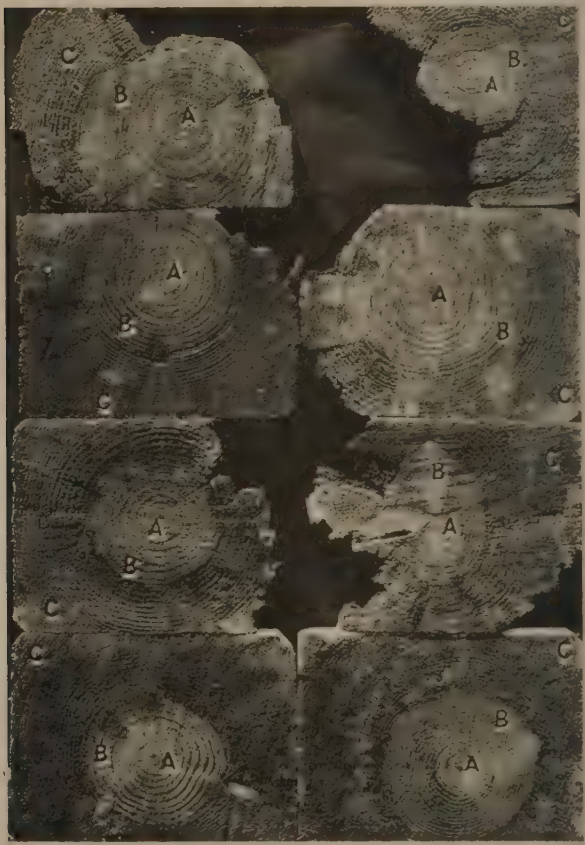


FIGURE 57. PER CENT ROSIN.

| Center A | Medium B | Outer C | Center A | Medium B | Outer C |
|---|---|---|---|---|---|
| 5.36 | 7.04 | .68 | 29.21 | 12.17 | .88 |
| 4.46 | 1.99 | .76 | 6.26 | 6.56 | .58 |
| 8.36 | 4.89 | 1.17 | 3.45 | 18.81 | .99 |
| 7.72 | 5.12 | .83 | 9.45 | 2.31 | .82 |

## DURABILITY AND PHOTOGRAPHIC ACTIVITY.

I have tried, by experiment, to learn if the photographic activity of different woods had any relation to their susceptibility to decay, but without success. Nevertheless, the facts found seem of sufficient interest to be mentioned.

**The resistance of wood to decay does not depend upon any one factor alone,** but is the result of many heterogeneous components acting together. The following phenomena may have some significance in this connection.

**Most woods after being exposed to strong light will act in the dark upon a photographic plate** placed in close contact with the specimen. There are several constituents of the wood which can cause this activity, including rosin, turpentine and the wood itself. The photographic activity is the result of an automatic oxidation reaction, to which many carbon compounds are subject. The action of wood on a photographic plate has been shown to be caused by hydrogen peroxide, or other form of active oxygen, given off when automatic oxidation is taking place.[1] The active oxygen may have some fungicidal power, but it alone cannot be of much antiseptic value, as the turpentine of the sapwood possesses the same property very strongly.

Russell gives the following order of photographic activity for some of the commoner woods: —

| Very Active | Moderately Active | Slightly Active |
|---|---|---|
| Oak | Cedar | Ash |
| Scotch Fir | Cherry | Elm |
| | Maple | Horse-chestnut |
| | Birch | |
| | Spruce | |
| | Locust | |

**The woods which are photographically active are also generally resistant to fungus, but this is evidently not a universal law,** as cedar and locust are grouped with maple and birch. The condition of the specimen, however, is an important factor. The photographic activity is much increased by light, and one at least of the photo-active substances in wood is soluble in water.

1. William J. Russell, Royal Society Transactions, Vol. 197, page 281, 1903. Royal Society Proceedings, Vol. 78, page 385, 1906.

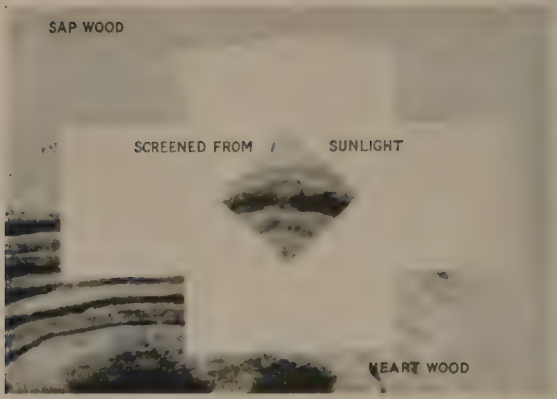


FIGURE 58. SHOWING THE EFFECT ON A PHOTOGRAPHIC PLATE OF HEARTWOOD AND SAPWOOD OF RED BIRCH WHICH HAD BEEN EXPOSED TO SUNLIGHT, PART OF IT BEING SCREENED BY A CROSS-SHAPED PIECE OF TINFOIL WITH A SQUARE HOLE IN THE CENTER.

It will be noted that the activity of the heartwood is more strongly increased by the sunlight than that of the sapwood. This phenomenon is also strongly marked in Southern pine and many other woods. The wood, after being exposed to bright sunlight for about two hours, shielded by the tinfoil, the tinfoil was removed and the wood was placed in contact with a rapid photographic plate and left in total darkness for a week. At the end of that time, the plate was developed in the customary manner, the image obtained being that shown in the picture. The heartwood had made a strong impression on the plate, excepting where it had been shielded from sunlight by the tinfoil. Exposure of the specimen of wood, either to direct sunlight or to a moderately elevated temperature, just prior to contact with the sensitive plate, apparently produces a similarly increased photographic activity.

## DENSITY AS AN INDEX OF STRENGTH.

**The proportion between spring and summerwood has been suggested as a criterion for grading timber.** This is now being favorably considered by some of the larger lumber manufacturing associations, and is undoubtedly much in advance of present methods, as timber containing much summerwood is generally dense and strong. The proportion is difficult to determine with precision, however, particularly in material with fine or uneven grain. It is to be expected that a beam of irregularly distributed density will vary in strength, with the lighter wood located at the neutral axis, or at the part of maximum stress.

**Weight per cubic foot of dry wood is a more accurate index of strength** than the proportion of summerwood in the annual growth rings, which has been recommended as the best index of quality, and it can be obtained with greater precision.

**Light-weight wood is simply wood without much wood in it,** in other words, **all wood would weigh about 100 lbs. per cubic foot if it were solid. The difference between this and the actual weight gives the proportion of air spaces that it contains,** as shown by the following photomicrographs, made by the author, of transverse sections of Southern pine. See Figures 59, 60, 61 and 62.

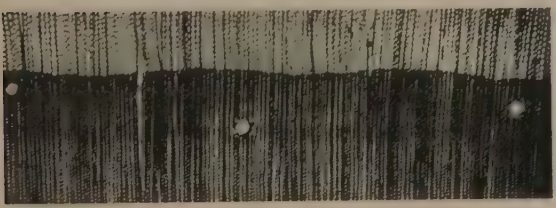

FIGURE 59. LINE BETWEEN SPRING AND SUMMERWOOD. MAGNIFIED ABOUT 15 DIAMETERS.

FIGURE 60. VERY LIGHT SPRINGWOOD. MAGNIFIED ABOUT 400 DIAMETERS.

FIGURE 61. MODERATELY LIGHT SUMMERWOOD. MAGNIFIED ABOUT 400 DIAMETERS.

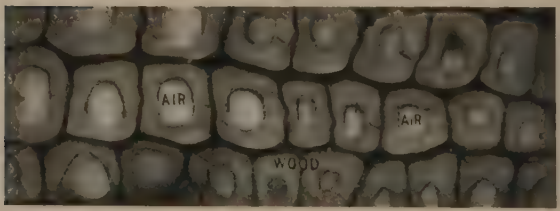


FIGURE 62. VERY DENSE SUMMERWOOD. MAGNIFIED ABOUT 400 DIAMETERS.

**Density has been shown by numerous tests** of the United States Forest Service **to be a reliable index of strength of timber.**

The proportionality between density and strength in the middle of its range (from 30 to 40 lbs. with the longleaf pine, is considerably obscured by other variables, such as season cracks, knots, cross grain, etc., as shown in tests given by the United States Forest Service.[1] The range of density of shortleaf and loblolly is somewhat lower; therefore, only the best of these varieties will have a density above 30 lbs. per cubic foot, and most of the poorer longleaf pine will have a density below this amount.

Photo-micrographs made by the author, of transverse sections of Southern pine of various densities, illustrate that density or weight per cubic foot is simply a measure of the amount of real wood present as distinct from air-filled cells.

Johnson[2] gives the following rule: "Cross-breaking strength of all timbers, except the oaks, in pounds per square inch = 300 times dry weight in pounds per cubic foot."

The tests given by the Forest Service indicate that not much more than one-half of this amount can be depended upon with structural sizes of longleaf pine of average quality, the figures given being:

Longleaf timber, green, 35 lbs. per cubic ft. dry weight, has a modulus of rupture of 6140.

Longleaf timber, air seasoned, 39 lbs. per cubic ft. dry weight, has a modulus of rupture of 5691.

Among the specimens from which these averages are taken, there is apparently only one below 32 lbs. per cubic ft.

The moisture contained in wood is an important factor in its strength, as shown by many tests made by the United States Forest Service,[3] longleaf pine and spruce increasing about 300% in strength as the moisture is reduced from 30% to 0.

1. Bulletin 108, "Tests of Structural Timber."
2. J. B. Johnson, Materials of Construction, 1912, page 680.
3. Bulletin No. 70, Effect of Moisture on the Strength and Stiffness of Wood.

## SPECIFICATIONS FOR STRUCTURAL TIMBER.

Many of the specifications for Southern pine in common use are vague or meaningless owing to the fact that the terms used are not clearly defined or are not determinable. For example, —

"Best quality" could honestly be taken to mean either the best in the local market, or the best in the world.

"Longleaf pine" in the form of lumber is practically impossible to identify beyond a doubt. "Shortleaf Cuban" and "loblolly" are regularly sold as "commercial longleaf." It can only be distinguished with positive certainty in the growing tree.

"Georgia" is sometimes added to a specification for pine, but lumber grown in that state is seldom insisted upon, nor is its place of growth important. Some of the best Southern pine lumber now obtainable comes from Florida, Alabama, Mississippi, Louisiana and Texas.

### Specifications of the American Society for Testing Materials.

**The definition which has heretofore been adopted by the American Society for Testing Materials practically calls all good material "longleaf pine" and poor material "shortleaf pine."** The exact words being as follows:[1]

> "Southern Yellow Pine." Under this heading two classes of timber are used, *a*, Longleaf Pine, *b* Shortleaf Pine.
>
> It is understood that these two terms are descriptive of quality, rather than of botanical species. Thus, shortleaf pine would cover such species as are now known as North Carolina pine, loblolly pine, and shortleaf pine. "Longleaf Pine" is descriptive of quality, and if Cuban, shortleaf or loblolly pine is grown under such conditions that it produces a large percentage of hard summerwood, so as to be equivalent to the wood produced by the true longleaf, it would be covered by the term "Longleaf Pine."

This is unfortunate in giving a double meaning to the names longleaf and shortleaf, which already have a generally accepted botanical meaning, and it is incomplete in not clearly defining the characteristics of the two classes.

1 American Society for Testing Materials, Year Book 1913, pages 302 and 404.

The following are a part of the specifications for yellow pine bridge and trestle timbers. No specific specifications for other structural timbers have as yet been made by this organization.

"Except as noted, all timber shall be sound, sawed to standard size, square-edged and straight; shall be close-grained and free from defects, such as injurious ring shakes and cross grain, unsound or loose knots, knots in groups, decay, or other defects that will materially impair its strength.

**Standard Size of Sawed Timber.** Rough timbers sawed to standard size shall mean that they shall not be over ¼ inch scant from the actual size specified. For instance a 12 by 12 inch timber shall measure not less than 11¾ by 11¾ inches.

**Standard Dressing of Sawed Timber.** Standard dressing shall mean that not more than ¼ inch shall be allowed for dressing each surface. For instance, a 12 by 12 inch timber after being dressed on four sides shall measure not less than 11½ by 11½ inches.

STRINGERS.

**Standard Heart Grade. Longleaf Yellow Pine.** Shall show not less than 85 per cent heart on the girth anywhere in the length of the piece; provided, however, that if the maximum amount of sap is shown on either narrow face of the stringer, the average depth of sap shall not exceed ½ inch. Knots greater than 1½ inches in diameter shall not be permitted at any section within 4 inches of the edge of the piece; but knots shall in no case exceed 4 inches in their largest diameter.

**Standard Grade. Longleaf and Shortleaf Yellow Pine.** Shall be square-cornered, with the exception of 1 inch wane on one corner. Knots shall not exceed in their largest diameter one-fourth the width of the face of the stick in which they occur, and shall in no case exceed 4 inches. Ring shakes shall not extend over one-eighth of the length of the piece."

There are also given at length definitions of standard defects, including knots, pitch pockets, shakes, wane, red heart, etc., for which the reader is referred to the Year-Books and Proceedings of this Society.

The committee on grading structural timber, of this Society, has been enlarged within the past year and several subcommittees have been recently formed in anticipation of formulating more reliable specifications.

**Interstate Rules for Grading Lumber.**

**The Interstate Rules for Yellow Pine Lumber** for 1905 define "Prime Quality, Dimension Sizes," as follows:

> "All square lumber shall show two-thirds heart on two sides, and not less than one-half heart on two other sides. Other sizes shall show two-thirds heart on face and show heart two-thirds of length on edges, excepting when the width exceeds the thickness by three inches or over, than it shall show heart on the edge for one-half the length."
>
> Merchantable Inspection. "All sizes under nine inches shall show some heart entire length on one side. Sizes nine inches and over shall show some heart the entire length on two opposite sides," etc.

The specification for "prime quality" loses most of its force when applied to pine of the type shown in Fig. 57. The young heartwood has rotted nearly as rapidly as the sapwood. Timber of merchantable inspection, in addition to the uncertainty of the heartwood mentioned above, has the practical certainty of rot in the sapwood if conditions are not most favorable. *This grade is particularly treacherous with the deep narrow sections frequently used for double beams.*

The above specifications all refer chiefly to heart and sap and sizes, and have little real relation to strength or durability or to need of treatment, such as kyanizing, to make the lumber really worth putting into a building.

**Specifications of Georgia-Florida Saw Mill Association.**

**The following specifications have been adopted within the past year by the Georgia-Florida Saw Mill Association** as a basis for grading structural timber.

> "For timbers and dimension, there must show on the cross section between the third and fourth inch measured radially from the heart center or pith, not less than six annual rings of growth, a greater number

of which shall show at least one-third summerwood, which is the dark portion of the rings of growth. Wide ringed material excluded by this rule will be acceptable, providing that in the greater number of the annual rings the dark ring is hard and in width equal to or greater than the adjacent light colored ring. In all cases there must be sharp contrast in color between the spring and the summerwood.

For sizes where the center cannot be determined, the following will apply: There must show on the cross section an average of not less than six annual rings of growth, with not less than one-third summerwood, and otherwise as provided for in paragraph I."

**Proposed Specifications of Yellow Pine Mfrs. Association.**

The Yellow Pine Manufacturers' Association were considering the following before that organization disbanded

"The classification of structural material is a question of strength and durability.

In untreated material this can best be determined by its density, as represented by the proportion of summerwood to springwood in the annual growth rings.

Growth rings are composed of bands of hard, dark, resinous summerwood, and lighter, softer, less resinous, springwood in each growth ring, and the greater the proportion of summerwood, the greater the strength and durability of the timber.

Dense wood shows on cross section an average of not less than eight growth rings per inch, measured over the third, fourth and fifth inches, on a radial line from pith to circumference, containing in the greater number of the rings one-quarter or more of summerwood, or, may have an average of six or seven rings as above, provided in the greater number of rings one-third or more of the ring is summerwood or wider ringed material if in the greater number of rings one-half or more of the ring is summerwood as above, and must show a sharp contrast in color between springwood and summerwood."

**These rules just quoted are based on observations of the U. S. Forest Products Laboratory,** part of which are given in Bulletin 108. Both are much in advance of present grading methods.

This bulletin calls attention to the important influence on the strength of a beam which the location of defects has. A large knot near the center or neutral axis of a beam will affect its strength but slightly, while the cross-grain caused by smaller knots will decidedly reduce the strength if located on the sides where the beam is in greatest tension or compression. A number of tests are given showing the effect on the strength, of defects so located. It has therefore been suggested that the surface of beams be divided into three areas for grading purposes and that larger knots be permitted in the central area near the neutral axis than in the outer tension and compression areas.

By similar reasoning, it would be expected that timbers which have the lightest part of their wood at the outside and the heaviest in the center would have the strength corresponding to the lightest wood instead of that corresponding to the average.

The grain band rule is based on strength and is only indirectly connected with durability. Heavy, close grained longleaf pine has proved durable in structures, probably because such wood is also generally resinous. For the fine grained shortleaf having the required percentage of summerwood, which will be admitted under these rules, durability is uncertain.

## What is Needed in a Specification.

**The ideal specification is undoubtedly a clear description of the qualities required** In structural timber these are strength and durability. With these qualities defined, attributes such as botanical variety, or location of growth, lose much of their importance. The limits of strength can be easily given, but not easily determined, without destroying the piece in question. The density is a sufficiently close index of strength for commercial purposes. The percentage of summerwood would undoubtedly serve every purpose for describing the required material except that in case of dispute this is difficult to measure precisely. In order to provide a definite standard, easily used or applied, the minimum acceptable density should be given in pounds per cubic foot dry.

From all information thus far available, the percentage of rosin is the most reliable index of durability for the Southern pines. The dark, greasy appearance of the summerwood will be sufficiently reliable for grading purposes under ordinary conditions. This is implied, if not clearly stated, in the statement in the above specifications, "must show a sharp contrast in color between springwood and summerwood." **In order to avoid misunderstandings and to settle disputes, a clear statement should be made of the minimum percentage of rosin that will be accepted.**

**Branding as a Guarantee.**

It has been suggested by Mr. Weiss, Director of the United States Forest Products Laboratory, that longleaf pine timber should be branded by the manufacturers. This is an excellent idea. Under present conditions the manufacturers are the only people who can positively say whether the timber is longleaf or not, as the standing loblolly, longleaf and shortleaf timber exhibits the distinguishing difference in bark, leaves and cones, not shown when cut into lumber. See Figures 63, 64 and 65.

FIGURE 63.
LONGLEAF PINE.

FIGURE 64
SHORTLEAF PINE.

FIGURE 65.
LOBLOLLY PINE.

**After the trees are cut into lumber, it is practically impossible to check grades based upon botanical varieties.**

Branding, without a clearly defined description of the several grades of wood, which can be checked by methods within the power of the purchaser, will depend entirely for its value upon the honesty and carefulness of the lumber manufacturer; but, with well defined physical and chemical specifications, such as those in common use with iron and concrete, the branding can be checked by the purchaser when necessary and will facilitate inspection on the job.

**True Conservation.**

Much is being written by students of forestry on the closer utilization of the forests. This is undoubtedly a commendable field of endeavor, but **the utilization should be permanent and not consist in simply passing the loss along from the lumber manufacturer or dealer to the owner of the building.**

The use of timber, which, without antiseptic treatment, is not durable, in an important structure where it will rapidly rot and cause a loss of at least double its own value, is not proper utilization since it soon results in economic waste of the most prodigal sort.

## CHEMICAL TREATMENTS TO PREVENT ROT.

**Antiseptic treatment is the only practicable procedure for lumber of doubtful durability, because of its porosity, light weight, sap or previous exposure to infection, or when it is to be used in a moist atmosphere.**

Much attention has been given to the treatment of railroad ties, posts, or other material intended for use near or in contact with the earth. But little study has in the past been given to the antiseptic treatment of mill timber. The well-known natural resistance of good longleaf pine in past years has been considered sufficient to guarantee the permanence of structures. This is undoubtedly sound judgment when good quality, dense, resinous longleaf pine is used, as experience in the older mills has clearly shown, but **the ordinary quality of pine now commonly used for heavy mill frames does not have this natural resistance.**

**The use of this ordinary quality of timber, unsatisfactory though it be, has become a necessity. With antiseptic treatment and reasonable allowance for the difference in strength between light weight and dense timber, the quicker growing varieties will fill the requirements of the future as satisfactorily as the longleaf Southern pine has done in the past**; but the use of light, sappy, quick-growing varieties of pine, under conditions now found in many kinds of factories and other structures, without antiseptic treatment has been and will be followed by disaster.

There is not yet experience enough with factory timbers to prove just how great an increase in life will be given by antiseptic treatment. Much depends on the exposure. Some idea may be had by the greater life of the dense "old fashioned" Georgia pine as compared with some of the timber received to-day. Some idea also may be had from the increase of life given ties and telegraph poles by various processes, and by the experience with timber kyanized many years ago at Lowell and exposed under conditions that invited decay.

**The increased life of railroad ties due to antiseptic treatment,** is given by Clyde H. Teesdale[1] of the United States Forest Products Laboratory, as follows:

| | Untreated Years | 10 lbs. Creosote per cubic foot. | ½ lb. Zn. Chloride per cubic foot. |
|---|---|---|---|
| White oak | 8 | | |
| Longleaf pine | 7 | 20 | |
| Douglas fir | 6 | 15 | 11 |
| Spruce | 6 | 14 | 11 |
| White pine | 5 | 14 | 10 |
| Tamarack | 5 | 15 | 11 |
| Hemlock | 5 | 15 | 11 |

The following table gives the increased life of telegraph poles in Germany and Austria, after being treated by several preservative processes, as given by Dr. Frederick Moll,[2] from Government records.

| | |
|---|---|
| Untreated poles | 4.5 years |
| Treated with zinc chloride | 12.2 " |
| Copper sulphate (Germany) | 14.5 " |
| Copper sulphate (Austria) | 12.3 " |
| Bichloride of mercury | 16.5 " |
| Creosote (15 lbs. cubic foot) | 23.0 " |

**What kind of antiseptic treatment shall be used is an important question.** Numerous compounds have been proposed. The problem of treating timber for factory construction is different from that of railway ties and posts. Increased fire hazard, resistance to paint, and a disagreeable odor are of no importance with ties or posts, but are of great importance with factory timber. Moreover, the leaching action of rain or ground water is important with posts and ties and of no importance in buildings where the material is protected from the weather. For this reason, the numerous creosote and tar compounds in extensive and successful use with ties are less suited to treating factory timber. The metal salts, such as corrosive sublimate, are preferable according to all the evidence thus far available.

1. American Lumberman, September 26, 1914.
2. American Wood Preservers Association, Proceedings 1914, page 237.

**The fungus-destroying power of various antiseptics has been carefully studied by several investigators.** The following table is given by Falck.[1] This not only gives the relative toxic power of the several materials, but the comparative value. The results are derived from laboratory experiments on germinating spores and fungus grown on various media. This must be given due consideration in estimating the practical value of the materials as preservatives. More reliable tests are those which are carried out over long periods of time under the conditions of actual service. Toxic materials may be either volatilized and removed, or chemically changed and thereby made inert, or they may combine with reactive parts of the wood.

By "inhibition concentration" is meant that strength which is just sufficient to destroy the fungus under investigation.

| Material. | Inhibition Concentration. Parts in a Thousand. | Price per Pound Multiplied by Inhibition Concentration. |
|---|---|---|
| Phenol | 1. | 50 |
| Dinitro-o-cresolate of soda. | .05 | 56 |
| 2:4 dinitrophenolate of soda | .05 | 10 |
| Silicon magnesium fluoride | 1. | 100 |
| Sodium fluoride | 1. | 75 |
| Boracic acid | 2. | 114 |
| **Corrosive sublimate** | 1. | 520 |
| Sulphate of copper | 10. | 550 |
| Chloride of zinc | 5. | 215 |
| Sulphate of iron | 20. | 280 |
| Salt | 100. | 1000 |

As a result of his investigations of a large number of different proposed toxic materials, Falck recommends the sodium dinitrophenolate, which is shown to be the most powerful fungus poison in the above list. This chemical is practically unknown in this country, and no experience with it as a wood preservative is available. Its chemical formula indicates a readily combustible substance although it is stated that its explosive qualities have been overcome.

1. Hausschwammforschungen, Vol. 6, page 377.]

Experiments made in the mines of France[1] with "Antinonnine" showed it to be much less efficient than creosote as a wood preservative. This material is stated to be dinitrocresolate of potassium. From the chemical similarity, it would be expected that its action would not be much different from that of the dinitrophenolate and cresolate of soda given above.

**Sodium fluoride shows up very favorably in the above list.** Its low price and high antiseptic value commend it. Experience with it as a wood preserver is lacking. It is certainly worth trying and it is hoped that in the near future some experiments can be made with this material for treating factory timber.

Dean and Downs[2] give the toxic value of creosotes from laboratory tests as follows:

| | | Inhibition Concentration. Parts in a thousand. |
|---|---|---|
| A | Coal tar creosote No. 1 | below 1 |
| B | Coal tar creosote No. 2 | 1 |
| C | Water gas tar creosote No. 1 | 4 |
| D | Water gas tar creosote No. 2 | 3.5 |
| E | Pressed anthracene oil | above 8.5 |
| F | Sample A minus the phenols | 3 |
| G | Sample A minus the phenols & tar bases | 6 |

Materials which are in no sense poisonous can resist fungus successfully, as in the case of the wood cells filled with water. It is probable that the beneficial result from some of the tars is caused by their waterproofing qualities. On the other hand, well-known bacterial antiseptics may be worse than useless for treating wood, as is shown by a building in Italy in which chloride of lime was used on the timber.[3] The chloride of calcium left in the wood cells attracted water and the building was quickly destroyed.

**Coal tar compounds are more used for preservative treatment of wood than all other materials together.** They act mechanically and chemically, serving as waterproofing

1. Preservation des Bois. E. Henry, 1907, page 19.
2. Antiseptic Tests of Wood Preserving Oils, Dean & Downs, Journal of Industrial and Engineering Chemistry, Vol. 5, page 126, 1912.
3. Atti del Reale Institute Veneto di Scienze Letters ed Atti, 1904, Vol. XLIV, Parti 1.

as well as antiseptics. There has been more or less controversy as to the value of carbolic acid, naphthaline and other constituents.[1]

Most of the tar products used are by-products of the gas industry, and it is not a question of the most toxic material, but of the most toxic material with reasonable consideration of cost and permanence.

**Many proprietary compounds are being sold for timber treating. The price is generally high,** ranging from fifty cents to a dollar a gallon. Coal tar creosote can be bought for much less, and, judging from laboratory experiments of the U. S. Forest Service,[2] as well as practical tests in the mines of France[3], **creosote is fully as serviceable** as an antiseptic where a coal tar compound is required.

The following figures are taken from a paper entitled **"Toxicity of Various Wood Preservatives"** by C. J. Humphrey and Ruth M. Fleming of the U. S. Forest Products Laboratory.

| | Killing Point in parts per 1000. | |
|---|---|---|
| | *Fomes Annosus.* | *Fomes Pinicola.* |
| Wood tar (hard wood) . | 12.5 | 7.5 |
| Water, gas, tar creosote. | 4.5 to 400 | |
| Coal tar, creosote ..... | 5.5 | 2.25 |
| Avenarius carbolineum . | 52.5 | 3.00 |
| S. P. F. Carbolineum... | 22.5 | |
| C. A. Wood Preserver .. | 10 to 15 | |
| Sodium fluoride .. .... | 2 5 | 1.5 |
| Zinc chloride ..... | 5.0 | 7.5 |

It is apparent from these results that the toxic or killing power varies considerably with the variety of fungus. This is particularly marked with antiseptics of low toxic power, therefore the results of experiments, showing moderate toxic power, with a given fungus, must be applied with caution to other fungi. Preservative materials of higher toxic power show less marked variation with different fungi.

1. Preservation of Timber, Bolton, 1885.
2. C. J. Humphrey and Ruth M. Fleming. Journal of Industrial and Engineering Chemistry, Vol. 6, page 128, 1914.
3. Preservation des Bois, E. Henry, 1907.

The figures given on pages 85, 86 and 87 cannot be directly applied to the cost of timber treating processes in terms of dollars per thousand feet. They show only the relative quantities of the several materials required to obtain the same poisoning effect on certain fungi. The second column of figures on page 85 introduces the price per pound of the chemical in order to get a ratio of comparison; for example, if the corrosive sublimate required for a given penetration effect in an open tank treating process costs two dollars per thousand feet of lumber, the same antiseptic effect could be obtained with sodium fluoride at a cost of about two dollars divided by 520 and multiplied by 75, that is, 30 cents. The labor would cost the same in each case. If instead of an open tank process, a vacuum process is used, in which ten times as much solution is absorbed, the ratio still holds, that is, twenty dollars for corrosive sublimate and three dollars for sodium fluoride, although the toxic value pound for pound of the two chemicals is shown as the same, the difference being due to the price per pound.

**Various observations show that liquid oils do not thoroughly waterproof wood, and, from all evidence** obtainable, fungus is able to thrive about the same on oil soaked wood as upon wood without oil, if the conditions of humidity are favorable. An example of this is shown in the following photograph, which shows the under side of a piece of 3" hemlock plank from

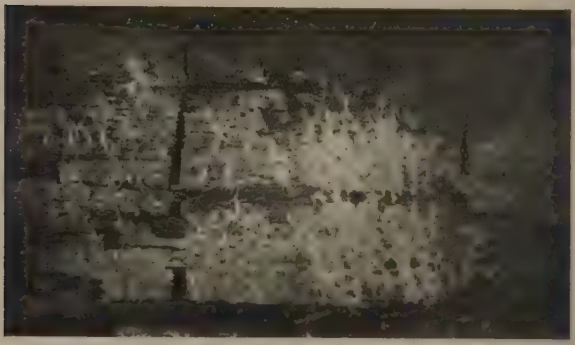

FIGURE 66. ROTTED 3" HEMLOCK FLOOR PLANKS. Although saturated with paraffine lubricating oil, the fungus continued to advance where the moisture was sufficient.

the floor of a cordage factory, taken from under spinning machines, where considerable quantities of moisture were being evaporated, raising the relative humidity locally to near the saturation point. Strips of flooring about 4 ft. wide, the entire length of the mill, were rotted under these machines, although this floor was thoroughly saturated with paraffine lubricating oil, so much so that the rotted wood removed dripped oil.

It is evident that the moisture in wood is to a considerable degree independent of the oil which it contains. In other words, there is room for both oil and water under certain conditions. An example of this is wooden casks of linseed oil or varnish, which dry up and allow the contents to leak out, if not kept in an atmosphere of sufficient humidity to keep the staves swelled tight. It is probable that the liquid state of the oil has considerable to do with this action, and that resin or wax will prove more efficient as a waterproofing agent. For example, a part of this floor which had rotted was repaired several years ago with resinous longleaf pine. This is still sound.

Coagulation of the albuminous compounds of the wood is frequently mentioned in the literature on wood preservation, as an important factor. Confusion exists as to the difference between simple coagulation by boiling, and combination with an antiseptic material. The former action could serve to sterilize already infected wood. This is one of the valuable results of kiln drying, but it in no way prevents later infection. A permanent combination of the antiseptic material with the wood can serve to prevent later infection. Bolton[1] is of the opinion that combinations between carbolic acid, or naphthaline, and wood albumen are of little importance, as the compound is easily broken up by water. He regards carbolic acid of little permanent value owing to its volatility.

### Creosoting, etc.

**The disagreeable odor, black, greasy surface and increased inflammability are objectionable qualities of the coal tar antiseptics.** In basement floors or rooms with wet occupancy, these objectionable qualities may not be prohibitive.

An oily antiseptic in considerable quantity on wooden ceilings can increase the fire hazard in sprinklered mills, as a fire once

1. Preservation of Timber, Bolton, 1885.

started can travel across the oil-soaked ceiling more rapidly than the sprinklers can open, involving large areas. The high flash point of the oil makes little difference because a thin film on wood, which is a poor conductor of heat, is rapidly heated by its own combustion to a sufficiently high temperature to burn rapidly. This action is decreased with time as the oil soaks deeper into the wood and the more volatile parts disappear. This action would be more serious in a building than in the open air where the heat would be rapidly carried away with the hot gases.

**Burnettizing by use of chloride of zinc is extensively used and has given generally satisfactory results for railroad ties.** It is understood to be considerably less expensive than creosote. There is, however, a suspicion that it may reduce the strength of the material. The action may be slow but continuous and accelerated by moderately elevated temperatures. In a report on the preservation of timber by a special committee of the American Society of Civil Engineers in 1885, it was stated that Burnettized bridge timber, that is, timber treated with chloride of zinc, was weakened 10% or more.[1] It was also stated that railway ties treated with this material gave better satisfaction kept away from light and air by a covering of earth.

Chloride of zinc is a well-known solvent of cellulose. It is probable that if the timber was not deeply treated or kept at a moderate temperature it would do little harm. However, with deep penetration or higher temperature, investigation is needed as to its effect on the strength of the timber before it is recommended for indiscriminate use in the important parts of a structure.

**Kyanizing.** Kyanizing by use of corrosive sublimate was patented in England in 1832. Since then it has been in limited but successful use.

The Locks & Canals Co., which is the Subsidiary Corporation owning the water power and is in turn owned by the mills of Lowell, Mass., commenced using this process in 1848 and have kept careful records of the results. For nearly half a century this concern was under the actual management of one of the ablest engineers in America, Mr. James B. Francis, who adopted

1. Transactions American Society of Civil Engineers, 1885, page 325.

Kyanizing after careful investigation and for more than sixty years maintained a small plant for treating such timber as needed about the canals or in the mills in places peculiarly subject to decay. Spruce was the timber mostly treated. Mr. James Francis[1] stated that kyanized fence posts were in service in 1891 that were set in 1850. It is understood that some of these posts are still in service sixty-three years after they were set. Timber parts of bridges, where conditions are exceptionally trying, remained in service thirty-two years. The bridge timber, however, was carefully selected and seasoned before treatment, a condition which may have somewhat added to the efficiency of the antiseptic.

The only failures of which I have been able to learn are basement floors where the planking was cut after being treated, thereby exposing the untreated center of the plank, for **the penetration is commonly only about one-quarter of an inch.**

The method of treatment employed is to soak the material in a cold 1% solution in a masonry, concrete or wooden tank, the time of soaking being arbitrarily set at a day an inch plus one, that is, for a beam 4″ x 10″, five days, and for one 6″ x 10″, seven days.

The solution attacks iron and other metals so that it is not found practicable to use it in metal tanks. It is claimed that the mercury once in the wood enters into chemical combinations with its albuminous constituents and becomes insoluble so that it cannot be leached out.

The Berlin Mills Co., an old and favorably known concern, has a Kyanizing plant and offers treated timber for sale.

**Several mills have recently treated roof planks with corrosive sublimate in their own yards.** Wooden and concrete tanks have been used. The concrete has proved most satisfactory from cost, tightness and convenience. The absorption of solution varies from four or five to forty per cent of the weight of the timber, according to the amount of sapwood and fungus in the wood, and also the state of seasoning of the timber.

1. Methods of Preserving Timber in Situations Which Expose It to Decay. James B. Francis. New England Cotton Manufacturers Association, Oct., 1891

**We recommend this process because of the half century of successful experience and the ease of application of the process and its economy.** Experience shows that the well known poisonous character of corrosive sublimate when taken internally by men or animals can readily be safeguarded, and, so far as I can learn, no sickness or death has ever resulted from the practical application of the process. In fact corrosive sublimate in very weak solution is one of the most widely used antiseptics in hospitals and sick rooms. Only common sense safeguards are needed, such as enclosing the tank and treating yard with a close fence, keeping the chemicals under lock and key and conspicuous "poison" labels attached to the tank. Preferably the treated lumber should be branded "Kyanized" with hot, thin edge iron letters an inch high.

Kyanizing has no objectionable effect on paint subsequently applied.

## A GREAT NEED FOR BETTER DATA.

On pages 85, 86 and 87, several preservatives have been listed, which promise well, but with most of them we lack experience in the practical application and as to the strength after ten or forty years, and as to their effect on paints, etc.

There is now the same need for experiments on the natural resistance and the effect of various kinds of preservation upon full sized beams and columns of commercially available timbers, under carefully controlled conditions of humidity and heat, and with exposure to known varieties of fungus, that existed a few years ago with reference to the strength of structural timber.

It is even less logical to generalize on the power of resistance to fungus of the several varieties of timber and upon the efficiency of timber treatments from laboratory experiments on small pieces in flasks, or small fungus pits where humidity, temperature and fungus are not carefully controlled, than it is to calculate the strength of large beams from tests on small specimens.

Moreover, experiments under practical service conditions do not give all the information desirable, for it has been shown that variations in atmospheric humidity, imperceptible without the use of carefully arranged measuring instruments, are sufficient to account for the wide differences observed in the destruction caused by common wood destroying fungi.

## KYANIZING TIMBER IN THE MILL YARD

FIGURE 67. SOUTHERN PINE HEARTWOOD ROOF PLANKS FOR A PAPER MILL, BEING TREATED IN A SHALLOW CONCRETE TANK, AT A COST OF ABOUT THREE DOLLARS PER THOUSAND INCLUDING THE COST OF THE TANK.

FIGURE 68. 4″ SPRUCE PLANKS AND SOUTHERN PINE BEAMS FOR A WEAVE SHED ROOF BEING TREATED IN A WOODEN TANK.

FIGURE 69. 2″ SOUTHERN PINE CONTAINING MUCH SAPWOOD, BEING TREATED FOR A WEAVE SHED ROOF. ABSORPTION VARIES FROM 5% TO 35% OF SOLUTION BY WEIGHT.

## PENETRATION OF ANTISEPTICS.

**The penetration of antiseptics has been increased by the use of vacuum and pressure processes**, applied in closed tanks. Alternate heating and cooling also increases the penetration. This process is sometimes carried out by dipping the timber first into a tank of hot material and then into cold, or by boiling it for a time and then allowing it to cool. By suitable manipulation, in addition to obtaining considerable depth of penetration, the wood cells can be left full or nearly empty, as desired. This method is based on the expansion and contraction of the air in the cells. A heating process might be used with corrosive sublimate to increase the penetration where this is necessary. It is probable that the present method with the cold bath is sufficient for mill lumber not subject to excessive moisture.

**The relative penetration of the different common woods by oily antiseptics** is given by C. H. Teesdale.[1] The depth of penetration is least with the first wood mentioned, and increases in the order given.

| | | | |
|---|---|---|---|
| 1 | Douglas fir heartwood | 7 | Loblolly pine heartwood |
| 2 | White spruce heartwood | 8 | White spruce sapwood |
| 3 | Eastern hemlock | 9 | Douglas fir sapwood |
| 4 | Western hemlock | 10 | Longleaf pine sapwood |
| 5 | Shortleaf pine heartwood | 11 | Shortleaf pine sapwood |
| 6 | Longleaf pine heartwood | 12 | Loblolly pine sapwood |

Miss Gerry[2] shows that the **tyloses**, which are a sack-like formation in the wood cells, are a factor in the durability of woods as well as the penetration of antiseptics. This action is attributed to the obstruction which these growths offer to the advance of the fungus as well as to the penetration of air and water. Durable woods generally have tyloses and they are especially effective in woods which have been dried.

**Brush treatments of timber** with antiseptic solutions have some value in retarding the progress of fungus as is shown by a recent Forest Service publication.[3] A recent experience in a weave shed basement shows that it is not safe to depend on brush treatment of timber already infected, if the antiseptic material depends chiefly for its preservative effect on its waterproofing qualities.

1. Bulletin 101, Department of Agriculture, Forest Service, 1914.
2. Journal of Agricultural Research, Vol. 1, page 462.
3. U. S. Dept of Agriculture, Forest Service Circular 198, Sept. 1912.

## COST OF TIMBER TREATING.

**The added cost of antiseptic treatment is not prohibitive.** The price quoted by treating companies varies from $8 to $15 per 1,000 feet board measure.

**The cost of treating with corrosive sublimate at certain factories insured by these companies has averaged about three dollars per thousand feet, B. M., for reasonably good timber.**

It is necessary to see that the material is not water-soaked, frozen, or already deeply infected with living fungus when treated. The ideal time and place of treatment is immediately after sawing at the saw-mill, as much of the lumber is undoubtedly infected long before it reaches its final destination. See Figure 70.

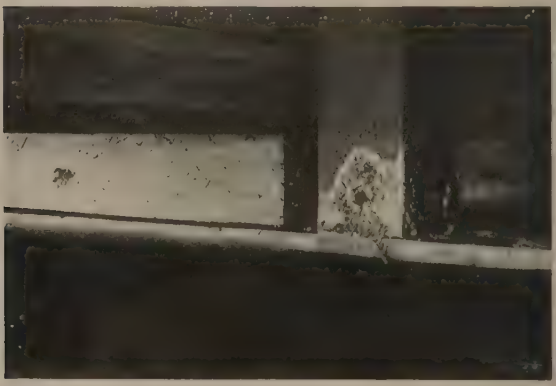

FIGURE 70. FRUITING *lachrymans* FUNGUS ON THE FRAME OF A LUMBER SHED AT A SOUTHERN SAW-MILL.

**A plan which commends itself** is to give the lumber a light treatment at the saw-mill with an antiseptic, such as sodium fluoride, which, being less poisonous than corrosive sublimate, would not prejudice it for common uses: then, after it is cut to final shape, to give it a second treatment suited to the conditions under which it is to be used. Indeed, corrosive sublimate applied in the small percentages required for timber preservation is very seldom objectionable.

## SUMMARY.

In conclusion, the following suggestions are made, based on observations and experience thus far: —

In building a paper mill or weaving mill, in which the atmospheric humidity will be high, **antiseptic treatment is well worth its cost** with any timbers now practicably obtainable. A creosote treatment of about twelve pounds per cubic foot is as good as anything in practical use for moist locations where the fire hazard is negligible and the lumber is to be near or in contact with the earth, but concrete is generally preferable to timber in such locations.

A form of construction for one story and basement paper mills and weave sheds which has many advantages, is a concrete floor, protected steel columns, and a heavy plank roof. When a concrete roof is used in a cold climate and there is high inside humidities, it is necessary to provide efficient insulating material on the outside to prevent the rapid conducting away of heat and consequent condensation. A dripping roof is highly objectionable for most occupancies. A thick wooden roof is the best heat insulator that can be had for the price. There are conditions under which it will be worth while, with this end in view, to increase the thickness of the roof to four or five inches. **For securing durability in such thick roofs, it will be absolutely necessary to use material that is thoroughly fungus-proofed with suitable antiseptics.** The roof should also be made sufficiently tight to prevent moisture laden air from passing through cracks against the cold outer covering where the condensed moisture will keep the planks water-soaked.

Thin plank roofs have been used in a few cases with fibrous insulating material on top, which can absorb water. The highly humidified air inside passed through cracks in the roof boards and saturated the insulating material with water, thereby destroying its insulating power and increasing the tendency to rot in the roof planks.

For roof planks over rooms where humidity is high, treatment with corrosive sublimate is undoubtedly worth its small cost. No experimental data is available as to the increased life to be expected from this treatment; but, judging from

experience with other uses to which kvanized material has been put, the life should be greatly lengthened.

For use on a roof where insulation is the first consideration, the planks being made extra thick to secure this end, low-grade material can be used if it is sufficiently resistant to rot; knots, shakes or resin pockets are of little importance if the material is thoroughly rot-proofed.

For ordinary dry mills where the average humidity is 50% or less, it may be possible to obtain Southern pine with sufficient natural resistance to withstand fungus, untreated, if sufficient care is given to its selection. According to present usage, the words "longleaf" and "shortleaf" in connection with Southern pine lumber are meaningless. Heartwood in all varieties is necessary for durability.

**The following suggestions for specifications are offered for use when Southern pine timber of an excellent quality is required.**

The following paragraphs will serve to eliminate much of the shortleaf, loblolly, and poorer qualities of longleaf, as well as to prevent misunderstandings and to facilitate the settlement of disputes if added to the specifications describing the required limitations of grain bands per inch and percentage of summerwood, as adopted by the Georgia-Florida Saw Mill Association, given on page 78, and the common limitations of knots, windshakes, wane, etc.

**Specifications proposed.**

**DENSITY. No part of the material shall have a density of less than thirty pounds per cubic foot when tested by boring smooth holes one inch in diameter and two inches deep in the ends of the stick, drying to constant weight at 212° F. and weighing the borings and computing the density from the volume of the hole.**

**ROSIN. None of the heartwood shall show less than 4 per cent of rosin by weight when borings are taken with a one inch bit with a hole two inches deep dried to constant weight at 212° F., and extracted with benzole, the extracted rosin evaporated until it is not soft or sticky when touched with the finger at 70° F.**

**HEARTWOOD. Heartwood shall show the entire length in all four faces of every stick, and sapwood shall not extend more than two inches from the corner at any place, measured perpendicularly to the corner across the face.**

**DEFECTS. No timber with knots greater than one inch in diameter, or rot or injurious shakes will be accepted.**

**BRANDING. Longleaf pine sold under this specification shall be branded with the letters "F. M.," with the**

**name of the lumber manufacturer, the location of the saw-mill from which it comes, and the date of sawing, in letters at least one inch high.**

The above specifications will require selected longleaf pine from the butts of trees and will undoubtedly command a considerably higher price than "commercial longleaf pine." It will also be worth a higher price. It is a "grade" not known to the lumber trade at present. There is some of it in the South, but, by methods now in use, it is mixed with poorer timber and its good qualities are lost, as it is not the average, but the poorest that characterizes the lot.

**The place of shipment is no guarantee of the quality of the stock, as in most places where longleaf pine is growing there is also shortleaf and loblolly.**

In some places, the proportion of longleaf is greater than in others. The care and good reputation of the lumber manufacturer is of more importance in assuring good material than the place of shipment.

Spruce and hemlock are undoubtedly much less resistant to common timber destroying fungi than good quality Southern pine heartwood, and it is a safe rule to avoid the use of these woods without antiseptic treatment in any except the dryest locations.

New lumber frequently contains living fungi in a latent form which is difficult to detect. This difficulty is increased by the common practice at many lumber yards of planing the stock just before it is delivered. The only outward manifestation of fungus in the wood is frequently an inconspicuous brownish tinge. Nearly every lumber pile on careful examination will show a considerable proportion of fungus-infected sticks. In some cases these sticks contain tree fungi that are already dead and harmless. Living plants often start growing in the lumber pile, particularly if the weather is damp, showing lacelike growths between the sticks when the pile is taken down. Lumber showing such growths had best be given an antiseptic treatment if the conditions under which it is to be used are at all moist.

In several cases, serious rotting has been caused by timber which was water-soaked by being left uncovered during a long

season of rainy weather, and covered in without provision for drying. When it is necessary to use such water-soaked timber, it will be well worth while to hasten the drying as much as possible by use of the heating system.

Kyanizing can be conveniently done on the job by constructing a tank of concrete or plank of such shape that the material can be packed into it with the least possible voids. It should be weighted or held down with bolts so that it cannot float when the solution is added. This should consist of corrosive sublimate dissolved in water, one pound to twelve gallons of water. The lumber should soak in this solution for a week. The absorption will vary according to the quality and variety of the lumber from two or three per cent to forty per cent. Care must be used in handling the corrosive sublimate as it is very poisonous if taken internally.

**Heat Treatment.**

**When there is any suspicion of dry rot infection in a building, heating from time to time to 115° F., for a day or two by use of the steam heating coils, is well worth its small cost** for arresting the progress of a *lachrymans* or *Coniophora* infection. In a new building, it is particularly useful as the heat not only arrests these fungi, but assists in drying the timber, and thereby kills other fungi.

Drying a moist basement will arrest many of the common fungi that require about 100% atmospheric saturation. This can sometimes be accomplished better by a combination of heat and ventilation than by ventilation alone, as the heat reduces the percentage saturation where there is no water supply to keep it up by further evaporation. It is frequently difficult to get a circulation of air in a large basement without fans or other mechanical means. In some cases, air has been taken from a basement, which was giving trouble by rotting, for humidifying the mill, thus getting a return for the power required for driving the fan.

In an infected building, the fungus spores would be so generally distributed that the few brought up with the air currents would add little to the chance of infection of the upper parts of the building, which are drier, and therefore the possibility of the spread of the fungus from this source is remote.

One pound of corrosive sublimate dissolved in twelve gallons of wood alcohol has been used with apparent success on several occasions for local or surface fungus infections. In some cases, this material has been injected into small holes bored in large beams; and, in others, if has been applied to the surface with whitewash brushes.

The additional cost of the alcohol solvent is only worth while under exceptional circumstances, such as timber already in place in a moist location, or when economy of time is imperative.

F. J. HOXIE.

INDEX

ABSTRACT 2

RECENT PROGRESS 4

EXTENT OF THE DESTRUCTION 6

The loss to Mutual Mills from rotting timber is many thousands of dollars a year 6

ROT AND FIRE HAZARD 11

Partly rotten wood ignites much more easily than sound wood 11

INCREASED COMBUSTIBILITY OF WOOD AFFECTED BY DRY ROT 13

SUGGESTIONS FOR EXAMINING AN INFECTED MILL 14

HOW WOOD ROTS 17

COMMON TIMBER DESTROYING FUNGI 18

There are but few common or popular names for fungi 18

Fruiting fungi can be easily identified 20

The dry rot disease is widely distributed in this country 20

The name *Polyporus* family has been used to include broadly any of the pore fungi 21

In many cases owing to the absence of fruiting plants the fungus causing the destruction cannot be determined 22

MICROSCOPIC APPEARANCE 23

RAPID PROGRESS OF DRY ROT 24

In most cases the rotting found has taken place rapidly 24

EFFECT OF HUMIDITY ON THE PROGRESS OF ROT 25

Average relative humidity of a building heated to 60° F. 25

The relative humidity at any temperature is the percentage which the humidity found bears to that required for saturation 26

**DRY ROT AND DAMP ROT** 28

Most rot in mill timbers is caused by two groups of fungus, one thrives in dampness, the other in air relatively much drier. 28

**LOCAL DIFFERENCES IN EXPOSURE TO MOISTURE** 30

The relative humidity of air in a room or basement sometimes is very different in places only a few feet apart 30

Dry and wet are only relative terms 31

Certain processes of manufacture require the atmospheric humidity to be regulated within narrow limits 31

**WETNESS AND DRYNESS BOTH PREVENT ROT** 33

Wood of great antiquity has been found buried in clay in a perfect state of preservation 33

The weaving rooms of Cotton Mills are frequently maintained at a saturation of moisture of 70% to 80% during working hours 34

Limits of dampness required for growth of dry rot fungus 34

A possible source of moisture for supplying the requirements of a fungus growing inside a large beam is the decomposition of the wood itself 34

Ventilation not always a cure 35

Paint sometimes retards, sometimes accelerates rotting 35

The conditions for germination and growth of *Merulius lachrymans* have been mysterious 36

Long life of dormant fungi 36

Dry rot fungi have two methods of reproduction and can remain a long time in a resting state 36

How the dry rot disease is spread 37

**HEAT AND DRYING ARE USEFUL IN STOPPING ROT** 38

Often an infected building can be sterilized by skilful use of its heating system 38

Heat as a means of destroying *lachrymans* and *coniophora* in mill beams was tried 38

**HOLES IN COLUMNS AND DOUBLE BEAMS WILL NOT PREVENT ROT** 41

One of the reasons for bored columns and double beams has been to prevent dry rot 41

SLOW BURNING CONSTRUCTION 44
Laminated floor 45

VARIETIES OF TIMBER AVAILABLE 47
Varieties of timber available for mill construction are fewer than those available for railroad ties 47
It is a significant fact that much of the best longleaf pine timber produced in the South is being shipped to Europe 47

COMMON VARIETIES OF SOUTHERN PINE 48
There is much confusion in local names 48
The positive identification of longleaf pine lumber is difficult or impossible 48

SOUTHERN PINE AVAILABLE 56
This shows clearly the need of a system of grading by which the heavy resinous material can be separated 57
The present specifications for longleaf pine of the American Society for Testing Materials opens the way to such practices by giving a double meaning to the name longleaf pine. 58

ROSIN AS A CAUSE OF RESISTANCE OF WOOD TO FUNGI 59
The causes of natural resistance to fungi in wood are obscure and have been investigated but little 59
Heartwood is generally more resistant to fungi than sapwood 59
The preservative power of rosin is frequently mentioned as a matter of general observation 59
The inverse ratio of the loss of weight to the percentage of rosin is in as close agreement as could be expected 60
In some of the pines there is an abrupt increase in the rosin content at the heart line 61
The longleaf pine heartwood shows a wide variation in the rosin content 67
Under the present system of grading and selection of timber the only guarantee of durability is the proportion of heartwood 67
The percentage of rosin in the sound centers of rotted beams taken from a mill was determined in order to get an idea of the amount at which the fungus stopped 68

It is apparent that the limiting amount of rosin which is just sufficient to stop fungus is in the neighborhood of 3% 68

DURABILITY AND PHOTOGRAPHIC ACTIVITY 71

The resistance of wood to decay does not depend upon any one factor alone 71

Most woods after being exposed to strong light will act upon a photographic plate in the dark 71

The woods which are photographically active are also generally resistant to fungus, but this is generally not a universal law 71

DENSITY AS AN INDEX OF STRENGTH 73

Light wood is simply wood without much wood in it 73

The proportion between spring and summerwood has been suggested as a criterion for grading timber 73

DENSITY HAS BEEN SHOWN TO BE A RELIABLE INDEX OF STRENGTH OF TIMBER 75

SPECIFICATIONS FOR STRUCTURAL TIMBER 76

The specification which has been adopted by the American Society for Testing Materials 76

The Interstate Rules for yellow pine lumber 78

The following specifications have been adopted within the past year by the Georgia-Florida Saw Mill Association 78

PROPOSED SPECIFICATIONS OF YELLOW PINE MANUFACTURERS ASSOCIATION 79

These rules are based on observations of the U. S. Forest Products Laboratory 80

The ideal specification is undoubtedly a clear description of the qualities desired 80

Branding as a guarantee 81

After the trees are cut into lumber it is practically impossible to check grades based upon botanical varieties 82

Much is being written by students of Forestry on the closer utilization of the forest. 82

CHEMICAL TREATMENTS TO PREVENT ROT 83
Antiseptic treatment is the only practicable procedure with lumber of doubtful durability or when it is used in a moist atmosphere 83
The increased life of railroad ties due to antiseptic treatments 84
What antiseptic treatment shall be used is an important question 84
The fungus destroying power of various antiseptics has been carefully studied by several investigators 85
Sodium fluoride shows up very favorably in the above list 86
Coal tar compounds are more used for preservative treatment of wood than of other materials together 86
Many proprietary compounds are being sold for timber treating 87
"Toxicity of various wood preservatives" 87
Liquids oils do not waterproof wood 88
The disagreeable odor, black greasy surface and increased inflammability are objectionable qualities of the coal tar antiseptics 89
Burnettizing by use of chloride of zinc is extensively used and has given generally satisfactory results for railroad ties 90
Kyanizing by use of corrosive sublimate 90
Several mills have recently treated roof planks with corrosive sublimate 91

A GREAT NEED FOR BETTER DATA 93
Brush treatments of timber 95

PENETRATION OF ANTISEPTICS 95
The penetration of antiseptics has been increased by the use of vacuum and pressure processes 95
The relative penetration of the different common woods by antiseptic solutions 95

THE COST OF TIMBER TREATING 96
The added cost of antiseptic treatment is not prohibitive 96

SUMMARY 97
Specifications proposed 99
Heat treatment for emergency 101

# THE ASSOCIATED FACTORY MUTUAL FIRE INSURANCE COMPANIES

| | | | |
|---|---|---|---|
| 1 | MANUFACTURERS MUTUAL F. INS. CO., | *Providence,* | JOHN R. FREEMAN, Pres. |
| 2 | RHODE ISLAND MUTUAL F. INS. CO., | *Providence,* | JOHN R. FREEMAN, Pres. |
| 3 | BOSTON MFRS. MUTUAL F. INS. CO., | *Boston,* | J. P. GRAY, Pres. |
| 4 | FIREMEN'S MUTUAL INS. CO., | *Providence,* | F. W. MOSES, Pres. |
| 5 | STATE MUTUAL F. INS. CO., | *Providence,* | JOHN R. FREEMAN, Pres. |
| 6 | WORCESTER MFRS. MUTUAL INS. CO., | *Worcester,* | W. E. BUCK, Pres. |
| 7 | ARKWRIGHT MUTUAL F. INS. CO., | *Boston,* | R. W. TOPPAN, Pres. |
| 8 | BLACKSTONE MUTUAL F. INS. CO., | *Providence,* | WM. B. McBEE, Pres. |
| 9 | FALL RIVER MFRS. MUTUAL INS. CO., | *Fall River,* | C. S. WARING, Pres. |
| 10 | MECHANICS MUTUAL F. INS. CO., | *Providence,* | JOHN R. FREEMAN, Pres. |
| 11 | WHAT CHEER MUTUAL F. INS. CO., | *Providence,* | FRANK L. PIERCE, Pres. |
| 12 | ENTERPRISE MUTUAL F. INS. CO., | *Providence,* | JOHN R. FREEMAN, Pres. |
| 13 | MERCHANTS MUTUAL F. INS. CO., | *Providence,* | WM. B. McBEE, Pres. |
| 14 | HOPE MUTUAL F. INS. CO., | *Providence,* | FRANK L. PIERCE, Pres. |
| 15 | COTTON AND WOOLEN MFRS. M. I. CO., | *Boston,* | BENJ. TAFT, Sec. |
| 16 | AMERICAN MUTUAL F. INS. CO., | *Providence,* | JOHN R. FREEMAN, Pres. |
| 17 | PHILADELPHIA MFRS. M. F. INS. CO., | *Philadelphia,* | E. I. ATLEE, Pres. |
| 18 | RUBBER MFRS. MUTUAL INS. CO., | *Boston,* | BENJ. TAFT, Sec. |
| 19 | PAPER MILL MUTUAL INS. CO., | *Boston,* | R. W. TOPPAN, Pres. |

The Factory Mutual Fire Insurance Companies were originated eighty years ago, by certain prominent manufacturers of New England, for the purpose of lessening fire losses and providing insurance at actual cost. They confine their business mostly to large isolated manufacturing properties. They have improved the construction of buildings, introduced better fire protection, and each risk is subject to expert inspection at least four times per year. They insist upon "good housekeeping," complete automatic sprinkler protection, special fire pumps, ample water supply from at least two independent sources, and private watchmen.

These methods have resulted in preventing interruption of business by fire, and enabled the Mutual Companies to return to policy holders a large proportion of their premiums which otherwise would have been used in payment of heavy fire losses.

Unless there is more than $75,000 at risk as a base for carrying the cost of inspection and engineering service, these Companies seldom can afford to take the insurance.